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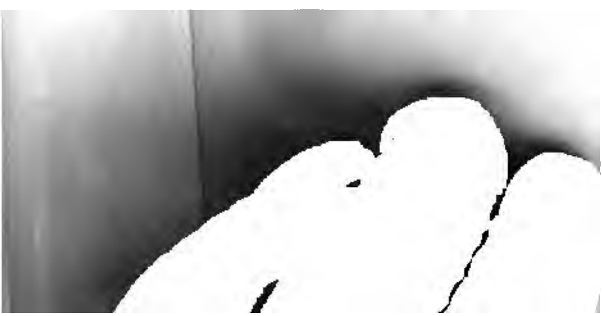

AMERICAN HANDY-BOOK

OF THE

BREWING, MALTING AND AUXILIARY TRADES

[redacted]

AMERICAN HANDY BOOK

OF THE

EWING, MALTING

AND

AUXILIARY TRADES

k of Ready Reference for Persons Connected with the
rewing, Malting and Auxiliary Trades, Together
with Tables, Formulas, Calculations, Bib-
liography and Dictionary of
Technical Terms.

COPIOUSLY ILLUSTRATED.

BY
ROBERT WAHL, Ph. D.
AND
MAX HENIUS, Ph. D.

Second Edition.

CHICAGO
WAHL & HENIUS
1902.

CORRECTIONS

PAGE	LINE	NOW READS	SHOULD READ
6	10 from bottom	$\frac{3}{8}$t	$\frac{3}{8}$
7	bottom line	$113\frac{3}{8}$	$113\frac{3}{8}$
18	10 from bottom	$3^2\times$	$3^2=$
52	10 from top	$(a\times b)$	$(a+b)$
60	9 from top	page 61	page 62
62	18 from top	50.26	50.24
147	under cut	Metorologie	Meteorologie
347	17 from bottom	$1\frac{1}{2}$ of	twice
347	5, 6, 10 and 14 from bottom	100 feet	132 feet
347	8 from bottom	50 pounds	65 pounds
347	3 from bottom	166 feet	198 feet
412	8 from top	Dextrose is not so, etc. (*wrong line*)	This sugar, also called glucose, grape or starch sugar, is
444	9 from top	0.14	0.014
447	lower table	*space in left of headings*	*insert* Grains per Gallon.
454	12 from bottom	endorsperm	endosperm
455	2 from bottom	melibiose	melitriose
456	5 from top	levulose	laevosin
456	6 from top	Tauret	Tanret
459	4 from top	matters and sulphur	*wrong line—cross out*
478	10 from bottom	-resin	α-resin
478	9 from bottom	-resin	β-resin
478	8 from bottom	-resin	γ-resin
478	14 from bottom	Bryan	Briant
506	2nd cut	pastorianum	pasteurianum
515	2 from bottom	saccharabacillus	saccharobacillus
517	14 from bottom	pastorianum	pasteurianum
535	14 from bottom	melibiose	melitriose
687	table	n extract	in extract
680	18 from top	laddle	ladle
718	12 from bottom	1877	1887
763	6 from top	the smaller	the larger
763	9 from top	ordinarily *to* barrel	need not be more than 50 per bbl.
763	10 from top	*add the sentence*	With filter use 5-20 chips per bbl. according to size of chip cask
765	15 from top	one-fourth	one-half
812	14 from bottom	saccharomyces	saccharo-bacillus
917	bottom line, 4th column.	34.95	33.95
927	9 from top	127.2 cents	127.9 cents
993	2nd formula	100+	700+
993	" "	grits	cereal
993	bottom	*formula should be* $\frac{\text{(Total yield}-\text{yield of 60 malt)}\times 100}{40}$	=yield of cereal
994	8 from top	it can be mashed directly	it is mashed directly at 67° C.
1012	5 from top	one end of which, etc.	1 sq. millimeter so that the volume of liquid between the
1087	15 from bottom	\$250	\$350
1214	16 from top	— water (Ils.) 488	442
1215	center, column 1	— oil testing, 15, 1040	315, 1040
1244	20 from top	melibiose	melitriose (melitose)
1261	21 from bott'm 2nd column.	— *composition of* 483, 853	484, 853

PREFACE.

THE AMERICAN HANDY-BOOK OF THE BREWING, MALTIN
AUXILIARY TRADES is designed to be a book of ready re
for the use of persons connected with the trades designat
does not pretend to be a text-book, which the student of b
will read through from beginning to end with a view of
ing acquainted with the principles and practice of this
industry. It aims to be, as it were, a pocket encyclopedia,
erence to which the brewer, maltster, refrigerating m
engineer, bottler, etc., as well as a person engaged in th
mercial activities of a brewery, may find an immediate
to questions that may come up in connection with the e
of his calling, without requiring him to wade through
volumes and peruse quantities of information in search of a
item of knowledge.

This purpose, kept steadily in view in the preparation
present volume, imposes many difficult tasks upon the co
and editors. While, on the one hand, it necessitates the b
range of information and the most complete collation o
possible, covering the entire science and practice of brewing
elementary arithmetic and algebra, through the physical sc
the rudiments of machinery, steam engines and refrigerati
theory and practical details of malting and brewing, the
lation of materials and cost of production, down to the
of tanking, casking, bottling and shipping, and the relati
the brewer to governmental agencies, yet, on the other h
is imperative to condense this information, much broader
it be in scope than that embraced in any of the text-boo
the smallest compass, both as to statement in words a

ve importance and magnitude would appear, a
irrant, while others, apparently of equal or g
:e, may be deemed to have been slighted in tl
and detail of statement devoted to them. H
epancies, in the judgment of the editors, are on
Where so much information is given, the w
rent classes of persons to whom the book will
onsidered.
ıking such allowance for these existing differen
ssary, and putting themselves, as far as lay ir
respect to each subject, in the position of the
ck solution of a problem that might arise in his
:, the editors gave to each of the several subjec
as seemed best to answer the requirements of
case. The result is that, while the treatment
ects may not seem strictly harmonious from
ie writer of a text-book, it is hoped that the w
irements of a book of ready reference far mo
wo rictly methodical arrangement and

methods. The American brewing industry, in a word, is an industry by itself. While it has profited much by the old country systems, it must look within itself for authority for its own operation and progress. No effort has been made, up to the present time, to produce a standard work on American brewing in the language of the country. In that respect, also, the American Handy-Book of the Brewing, Malting and Auxiliary Trades is first in the field.

It is manifest, from what has been said, that the plan of the present work was wholly novel—that the editors had no precedents to guide them, but were obliged to seek altogether new paths.

It is the common fate of all pioneer work that it is encumbered with many drawbacks and shortcomings, since it lacks the direction of the greatest of teachers—experience. The editors are conscious of the fact that the present work is no exception to the rule. They rely on the indulgent judgment of the brewing trade and its auxiliaries, and will welcome any well intended criticism, hoping to profit thereby for future editions of the book.

While a book of this character is naturally, to a great extent, a compilation of information from many other sources, the present volume contains much original work elaborated in the course of time by the Scientific Station for Brewing of Chicago. It may also be added that the editors derived much assistance in planning the book and treating the various subjects from their intimate association with brewers in their capacity as directors of that institution, and from studying the needs of students at the American Brewing Academy.

It being a matter of universal experience that the value of many a book replete with useful information is seriously impaired, for ready reference, by the absence of a complete and detailed index, which fact was brought home to the editors with peculiar force in the work of compilation connected with the preparation of the present book, special pains were given to the

of the book it need only be repeated that e
in accordance with the plan of a handy
book.

No innovations were attempted in the
pelling, preference being shown for that w
nderstood by all. However, the editors
elves of the example of United States go
adopting certain convenient forms, f. i., u
e decimal point, as 0.349, instead of the old
hich is too apt to be misread; or, dropping
here it exerts no influence on the pronuncia
lycerin," etc.

The editors indulge the hope that they ha
cessful in preparing a book of ready r
wing, malting and auxiliary trades will
secution of their work.

remains to express the gratitude of the e
sted them in the preparation of this book

PREFACE TO SECOND EDITION.

The hope indulged by the editors in the preface to the first edition, that they may have been measurably successful in the preparation of this book, has been realized beyond all expectations, if the phenomenal sale of the first edition can be taken as a criterion.

After the Handy-Book was issued, it was accorded a most friendly reception and favorable review by the trade press of all countries, which, with the recommendation of its readers, soon exhausted the edition.

A second edition has become necessary in the short space of time of less than one year.

This second edition is substantially a reprint of the first, as only typographical errors have been corrected.

The editors wish again to thank those who have assisted them in the preparation of the book, also its many friends for the interest they have taken in the volume.

Robert Wahl,
Max Henius.

Chicago, April 30, 1902.

TABLE OF CONTENTS.

ARITHMETIC.

Arithmetic is the science that treats of numbers, and of the methods of computing by means of them.

"**Notation**" is a method of writing numbers by characters or figures. The number ten is the basis of our system of notation, containing ten numeral figures or "digits," 1, 2, 3, 4, 5, 6, 7, 8, 9, 0, the last, the cipher or zero, having no value except in combination. This system is known as the Arabic. (The Roman system uses the capital letters, I for 1, V for 5, X for 10, L for 50, C for 100, D for 500, M. for 1,000. An equal or a smaller figure placed after a bigger one is added thereto; a smaller one placed in front is subtracted therefrom. Thus, 1888 is represented as follows: MDCCCLXXXVIII; 67 = LXVII, 43 = XLIII. The use of this system is limited.)

"**Numeration**" is the art of reading figures employed to express numbers. The following table shows the places of the figures, which are grouped in periods of three figures each, counting from the right, commonly separated by commas.

Hundreds of Billions	Tens " "	Units " "		Hundreds of Millions	Tens " "	Units " "		Hundreds of Thousands	Tens " "	Units " "		Hundreds	Tens	Units
2	2	5	,	9	1	0	,	6	7	3	,	4	8	5

This is read two hundred and twenty-five billion nine hundred and ten million six hundred and seventy-three thousand four hundred *and eighty-five*.

Addition is the method of finding the "sum" of two or more given numbers. The sign of addition is $+$, reads "plus," and signifies "more."

"Equation" is an expression of equality of two numbers. The sign of equation is $=$, it reads "equals" or "equal to." Thus $3 + 4 = 7$, reads 3 plus 4 equals 7.

Subtraction is the method of finding the "difference" between two given numbers.

"Minuend" is the greater of the two numbers.

"Subtrahend" is the smaller of the two numbers.

"Difference" or "remainder" is the result obtained by subtracting. The sign of subtraction is $-$, reads "minus" and signifies "less." Thus $13 - 8$ is read "13 minus 8," and signifies that 8 is to be subtracted from 13.

Multiplication is a method of finding the result produced by a given number taken a given number of times.

"Multiplicand" is the number to be multiplied.

"Multiplier" is the number by which to multiply.

"Product" or "multiple" is the result of multiplication. Multiplicand and multiplier are called the factors of the product. The sign of multiplication is $\times$, reads "times" or "multiplied by."

Division is the method of finding how often one given number contains another.

"Dividend" is the number to be divided.

"Divisor" is the number by which to divide.

"Quotient" is the result of the division. The sign of division is $\div$, reads "divided by." Division is also indicated by placing the dividend above the divisor, with a line between them. Thus $\frac{63}{7}$ is read "63 divided by 7," in which 63 is the dividend, and 7 the divisor.

Properties of Numbers. An "integral number" or "integer" is a number representing whole things. It is either even or odd, prime or composite. "Even numbers" are divisible by 2; "odd numbers" are not exactly divisible by 2. 2, 6, 12, 14, etc., are even numbers. 3, 7, 13, 15, etc., are odd numbers.

"Prime Number" is a number which has no integral factors except unity and itself. 2, 3, 5, 7, 11, etc., are prime numbers.

"*Composite Number*" is a number that has other integral fac-

tors besides unity and itself. Thus 24 is a composite number, since $24 = 8 \times 3$.

"Factors" of a number are the numbers which multiplied together will produce such number. 9 and 7 are factors of 63.

"Prime Factor" is a prime number used as a factor, and is also the prime divisor of it; thus 3 and 5 are prime factors of 15, and prime divisors.

"Exact Divisor" of a number is one that will divide that number without a remainder. 7 is an exact divisor of 63. Exact divisors of a number are also the factors of that number.

Numbers are "prime to each other" when they have no common integral factor or divisor. 7 and 16 are prime to each other.

"Factoring" is the resolving of a composite number into its factors, and is done by division.

To find the prime factors of a composite number: Divide the given number by any prime factor of it, and the resulting quotient by another, and continue the division until the quotient is a prime number. The several divisors and the last quotient are the prime factors.

Prime factors of 2310 are:

```
2) 2310
3) 1155
 5) 385
  7) 77
     11
```

2, 3, 5, 7, 11

The product of all the prime factors is the given number.

A "Common Divisor" of two or more numbers is a divisor of each of them, and also a common factor of each of them. The "Greatest Common Divisor" of two or more numbers is the greatest "common factor," and is the product of all the common prime factors.

To find the greatest common divisor of two or more numbers: Resolve the given numbers into their prime factors; select the factors which are common, and multiply them together. The product will be the greatest common divisor. The greatest common divisor of 42 and 112 is:

$42 = 7 \times 3 \times 2$ Common to both figures are 7 and 2.

$112 = 7 \times 2 \times 8$ Hence $7 \times 2 = 14$ the greatest common divisor

or

```
2) 42  112
7) 21   56
    3    8
```

"Multiple" of a number is a number exactly divisible by th given number. 6 is a multiple of 2 and 3. A "common multiple of two or more given numbers is a number exactly divisible b each of them. The "least common multiple" is the least numbe exactly divisible by each of them.

To find the least common multiple of two or more numbers Resolve the given numbers into their prime factors; select al the different factors, taking each the greatest number of times i is found in any of the numbers, and multiply together the factor thus selected:

The least common multiple of 10, 45, 75, 90 is:

$$10 = 2 \times 5$$
$$45 = 3 \times 3 \times 5$$
$$75 = 3 \times 5 \times 5$$
$$90 = 2 \times 3 \times 3 \times 5$$

and $2 \times 3 \times 3 \times 5 \times 5 = 450$

Another method is to write the numbers in an horizontal lin omitting such of the smaller numbers as are factors of the large and draw a vertical line at the left. Divide by any prime fact that will exactly divide two or more of the given numbers, an write the quotients and undivided numbers in a line underneatl Divide the quotients and undivided numbers until they a prime to each other. The product of the divisors and the fin quotients and undivided numbers is the least common multipl

2	10	45	75	90
3	5	45	75	45
3	5	15	25	15
5	5	5	25	5
	—	—	5	—

$2 \times 3 \times 3 \times 5 \times 5 = 450$

or

2	10	45	75	90
3	5	—	75	45
5	5	—	25	15
	—	—	5	3

$2 \times 3 \times 5 \times 5 \times 3 = 450$

"Cancellation" is the process of abridging operations in divisio by rejecting equal factors from both dividend and divisor.

Divide $13 \times 7 \times 5 \times 3$ by $3 \times 5 \times 7$. Then

$$\frac{13 \times \cancel{7} \times \cancel{5} \times \cancel{3}}{\cancel{3} \times \cancel{5} \times \cancel{7}} = 13$$

$$\text{or, } \frac{84 \times 30}{15 \times 7} = \frac{\cancel{7} \times 12 \times \cancel{5} \times \cancel{6}\,2}{\cancel{3} \times \cancel{5} \times \cancel{7}} = 12 \times 2 = 24$$

FRACTIONS.

unity be divided into any number of equal parts, one or : of these parts is called a "fraction."

iere are two kinds of fractions: "Common" or "vulgar" ions, commonly called "fractions" simply, and "decimal" ions, commonly called "decimals."

common fraction is represented by two numbers, called ms," which are written one above, the other below an horial or slanting line, thus: $\frac{1}{2}$, $\frac{3}{8}$, $\frac{1}{4}$, $\frac{5}{6}$.

)enominator" of a fraction is the number of equal parts which the unit is divided, and is written below the line. s in $\frac{1}{4}$ the denominator is 4, showing that the unit is divided 4 equal parts.

Jumerator" of a fraction is the number of equal parts taken orm the fraction, and is written above the line. Thus: in ie numerator is 5, showing that 5 of the 6 equal parts are n or expressed by the fraction.

'roper fraction" is one whose numerator is less than its deinator; as $\frac{2}{3}$, $\frac{3}{4}$, $\frac{7}{8}$.

mproper fraction" is one whose numerator is equal to or ter than the denominator; as $\frac{4}{4}$, $\frac{7}{6}$, $\frac{9}{7}$.

Mixed number" is an integer and fraction united; as $4\frac{3}{4}$, $15\frac{7}{8}$.

REDUCTION OF FRACTIONS.

r "reduction" the form is changed, the value remaining the e. Fractions are changed to *higher terms* by multiplication, *wer terms* by division.

eduction to *higher terms:* $\frac{2}{3} = \frac{4}{6} = \frac{8}{12}$

eduction to *lower terms:* $\frac{8}{12} = \frac{4}{6} = \frac{2}{3}$

eduction to *lowest terms:* $\frac{12}{16} = \frac{3}{4}$

re numerator and denominator are *prime* to each other.

o Reduce an Integer or a Mixed Number to an Improper Frac-: Multiply the integer by the required denominator, and to the luct add the numerator of the fraction, and under the result e the required denominator.

to sixths $= 31 \times 6 = \frac{186}{6}$

$4 = 4 \times 9 + 3 = \frac{39}{9}$

o Reduce an Improper Fraction to an Integer, or a Mixed nber. *Divide the numerator* by the denominator, $\frac{36}{8} = 4\frac{4}{8} = 4\frac{1}{2}$.

A "common denominator" is a denominator common tc or more fractions. The "least common denominator" of t more fractions is the least denominator to which they can reduced.

To reduce two or more fractions to equivalent fractions h a common denominator: **Multiply the terms of each fracti the denominators of all other fractions.**

$$\tfrac{3}{7},\ \tfrac{5}{8},\ \tfrac{2}{3}.\quad 7\times8\times3=168.$$

$$\text{Then } \frac{3\times8\times3}{7\times8\times3}=\frac{72}{168}$$

$$\frac{5\times7\times3}{8\times7\times3}=\frac{105}{168}$$

$$\frac{2\times7\times8}{3\times7\times8}=\frac{112}{168}$$

To Reduce Two or More Fractions to Their Least Co Denominator: 1. Find the least common multiple of the dc nators of the given fractions for their least common denomi 2. Divide this common denominator by the denominator o of the given fractions, and multiply its numerator by the qu The products are the new numerators.

$\tfrac{2}{3},\ \tfrac{5}{16},\ \tfrac{3}{32}$, then $3\times32=96$, least common multiple.

$$96\div3=32\times2=\tfrac{64}{96}$$

$$96\div16=6\times5=\tfrac{30}{96}$$

$$96\div32=3\times3=\tfrac{9}{96}$$

ADDITION OF FRACTIONS.

1. *To add fractions*, reduce the fractions to equivalent tions with a common denominator, add the numerators of ti fractions, and under the sum write the common denominat

$$\tfrac{1}{2}+\tfrac{2}{3}+\tfrac{3}{4}+\tfrac{4}{5}=\tfrac{30}{60}+\tfrac{40}{60}+\tfrac{45}{60}+\tfrac{48}{60}=\tfrac{163}{60}=2\tfrac{43}{60}$$

2. *To add mixed numbers*, add the fractions and intege arately, and combine the results.

$$\begin{array}{rl} 45\tfrac{1}{2} & \tfrac{4}{8} \\ 67\tfrac{3}{4} & \tfrac{6}{8} \\ 62\tfrac{5}{8} & \tfrac{5}{8} \\ \hline 175\tfrac{7}{8} & \end{array}$$

SUBTRACTION OF FRACTIONS.

1. *To subtract fractions*, reduce the fractions to equivaler *tions with a common* denominator, subtract the numerator

subtrahend from the numerator of the minuend, and under the difference write the common denominator.

Subtract $\frac{3}{8}$ from $\frac{7}{12} = \frac{9}{24}$ from $\frac{14}{24} = \frac{5}{24}$

2. *To subtract mixed numbers,* subtract first the fractions and then the integers.

$2\frac{3}{4} - 1\frac{1}{4} = 1\frac{1}{2}$; $2\frac{3}{4} - 1\frac{2}{5} = \frac{15}{20} - \frac{8}{20} = \frac{7}{20}$ and $2 - 1 = 1 = 1\frac{7}{20}$

$$\begin{array}{rl} 108\frac{1}{2} & \frac{3}{6} \\ 90\frac{1}{3} & \frac{2}{6} \\ \hline 18 & \frac{1}{6} \end{array}$$

MULTIPLICATION OF FRACTIONS.

1. *To multiply an integer* by a fraction, divide the integer by the denominator, and multiply the quotient by the numerator; or, multiply the integer by the numerator and divide the product by the denominator.

$87 \times \frac{4}{5} = 87 \div 5 = 17\frac{2}{5} \times 4 = 69\frac{3}{5}$

2. *To multiply an integer* by a mixed number, multiply by the integer and by the fraction separately and add products.

$96 \times 23\frac{7}{8}$. $96 \times 23 = 2208$; $96 \times \frac{7}{8} = 84$; $2208 + 84 = 2292$.

$$\text{or} \quad \begin{array}{r} 96 \\ 23\frac{7}{8} \\ \hline 288 \\ 192 \\ 84 \\ \hline 2292 \end{array} \qquad \text{or} \quad \begin{array}{r} 96 \\ 23\frac{7}{8} \\ \hline 84 \\ 288 \\ 192 \\ \hline 2292 \end{array}$$

To multiply one fraction by another, multiply the numerators together and also the denominators, and reduce the resulting fraction to its lowest terms.

$\frac{5}{6} \times \frac{6}{13} = \frac{30}{78} = \frac{5}{13}$

DIVISION OF FRACTIONS.

To divide a fraction by an integer, divide the numerator or multiply the denominator.

$\frac{7}{11} \div 7 = \frac{1}{11}$; $\frac{7}{12} \div 10 = \frac{7}{120}$

To divide an integer by a fraction, multiply the integer by the denominator of the fraction, and divide the product by the numerator.

$63 \div \frac{9}{10} = 630 \div 9 = 70.$

$71 \div \frac{5}{8} = 568 \div 5 = 113\frac{3}{5}.$

To divide a fraction by a fraction, reduce the fraction to equivalent fractions with a common denominator, and divide the numerator of the dividend by the numerator of the divisor.

$\frac{6}{7} \div \frac{3}{4} = \frac{24}{28} \div \frac{21}{28} = 24 \div 21 = 1\frac{3}{21} = 1\frac{1}{7}$

$\frac{3}{8} \div \frac{1}{2} = \frac{3}{8} \div \frac{4}{8} = 3 \div 4 = \frac{3}{4}$

$\frac{3}{5} \div \frac{7}{9} = \frac{27}{45} \div \frac{35}{45} = 27 \div 35 = \frac{27}{35}$

Or, invert the terms of the divisor, and then multiply the numerators together, and also the denominators, and reduce the resulting fraction to the lowest terms.

$$\frac{6}{7} \div \frac{3}{4} = \frac{6 \times 4}{7 \times 3} = \frac{24}{21} = 1\frac{1}{7}$$

$$\frac{3}{8} \div \frac{1}{2} = \frac{3 \times 2}{8 \times 1} = \frac{6}{8} = \frac{3}{4}$$

$$\frac{3}{5} \div \frac{7}{9} = \frac{3 \times 9}{5 \times 7} = \frac{27}{35}$$

DECIMAL FRACTIONS.

Decimal Fraction is a fraction having for its denominator 10 or a number produced by multiplying 10 by itself a given number of times, that is, 100, 1,000, 10,000, etc. Decimal fractions may be expressed as follows:

1. By words, as three-tenths, sixty-hundredths, etc.;
2. By writing the denominator under the numerator, as $\frac{3}{10}$, $\frac{60}{100}$;
3. By omitting the denominator and writing the numerator in the decimal form, as .3, which reads "decimal three;" .67, which reads "decimal six seven;" 3.654, which reads "three, decimal, six five four."

"Decimal Point" is a period placed at the left of the order of tenths, to distinguish a *decimal* from an *integer*, as .45. Owing to the liability of confusion by the use of the decimal point alone (as .45) the continental style of writing decimals is gradually being introduced, which is 0.45, writing a cipher before the decimal point where it is a genuine fraction, i. e., less than 1. This style has been adopted by the United States Internal Revenue Office and a number of scientific institutions in this country, and will be followed in this book.

"Mixed Decimal Number" is an integer and a decimal written together as one number, as 3.45, and is also called a "mixed number."

The following table gives the names of six integral and six

decimal orders of units, denoted by the position of the figures used in expressing a number. Ten units of any order in a number make a unit of the next higher order:

Hundred-thousands.	Ten-thousands	Thousands	Hundreds	Tens	Units	Decimal Point	Tenths	Hundredths	Thousandths	Ten-thousandths	Hundred thousandths	Millionths
6	5	4	3	2	1	.	1	2	3	4	5	6

Integral Orders.—Increasing in value from right to left.

Decimal Orders. — Decreasing in value from left to right.

Decimal fractions thus appear as fractions of which the numerator only is written, the denominator being the continued product of so many tens as there are decimal figures.

In writing decimals, vacant orders must be filled with ciphers. Thus: 3.107 means 3 units, 1 tenth, no hundredth, 7 thousandths.

Annexing ciphers to a decimal, or decimal ciphers to an integer does not change its value; thus: $0.5 = 0.50 = 0.500$, etc., $3 = 3.0 = 3.00$, etc. Removing ciphers from the right of a decimal, or decimal ciphers from the right of an integer, does not change its value; thus: $0.125000 = 0.125$, and $365.00 = 365$.

To Reduce a Decimal to a Common Fraction in its lowest terms: Omit the decimal point, supply the proper denominator, and then reduce the fraction to its lowest terms.

$$0.25 = \frac{25}{100} = \frac{1}{4}; \quad 0.666 = \frac{666}{1000} = \frac{2}{3} \text{ nearly.}$$

To Reduce a Common Fraction to a Decimal: Annex ciphers to the numerator and divide by the denominator; point off as many decimal places in the result as there are ciphers annexed.

$$\frac{5}{8} = \frac{5000}{8000} = \frac{625}{1000} = 0.625; \quad \frac{1}{3} = \frac{1.0000}{3} = 0.3333 +$$

The sign + is sometimes placed after the result to indicate that there is *still a remainder.*

To Add Decimals: Write the numbers so that figures of the same order shall be in the same column, then proceed as in simple addition, and place the decimal point at the left of the tenths' order in the amount.

$$\begin{array}{r} 0.9503 \\ 11.007 \\ 3.4 \\ 120.15 \\ \hline 135.5073 \end{array}$$

To Subtract Decimals: Write the numbers so that figures of the same order shall be in the same column; subtract as in simple subtraction, and place the decimal point at the left of the tenths order in the remainder.

$$\begin{array}{r} 56.600 \\ 18.403 \\ \hline \end{array}$$

$$56.6 - 18.403 = 38.197$$

To Multiply Decimals: Multiply as in multiplication of integers, point off as many decimal places as there are decimal places in both factors.

$$3.25 \times 0.14 = 0.4550.$$

To Multiply a Decimal by 10, 100, 1000, etc.: Remove the decimal point as many places to the right as there are ciphers in the multiplier.

$$1.004 \times 100 = 100.4; \quad 6.05 \times 1000 = 6050.$$

To Divide Decimals: Divide as in the division of integers, and point off as many decimal places in the quotient as the number of decimal places in the dividend exceeds the number in the divisor. Ciphers must be added to the dividend to make its decimal places at least equal to those in the divisor, and as many more as it is desired to have in the quotient.

$0.625 \div 0.25 = 2.5$; $35.05 \div 2.0721 = 35.0500 \div 2.0721 = 16.9103 +$

To Divide a Decimal by 10, 100, 1000, etc.: Remove the decimal point as many places to the left as there are ciphers in the division.

$$0.045 \div 100 = 0.00045; \quad 340.12 \div 10 = 34.012.$$

PERCENTAGE.

"Per cent" is an abbreviation of Latin "per centum" and signifies "by" or "to the hundred." Its sign is %, and it reads "per cent."

Thus 1% reads "one per cent," or $\frac{1}{100}$, or 0.01, 5% reads "five per cent," $\frac{5}{100} = 0.05$; 15% reads "fifteen per cent," $\frac{15}{100} = 0.15$.

"Rate per cent" is the number of hundredths taken.

"Base" is the number of which the per cent is taken.

"Percentage" is the result obtained by taking a certain per cent of the base.

"Amount" is the sum of the base and the percentage.

"Difference" is the remainder found by subtracting the percentage from the base.

To find a given percentage of any number, multiply the number by the given rate percentage, and divide by 100.

$$33\% \text{ of } 63 = \frac{63 \times 33}{100} = \frac{2079}{100} = 20.79, \text{ or } 63 \times 0.33 = 20.79.$$

$$12\% \text{ of } 5 = \frac{5 \times 12}{100} = \frac{60}{100} = 0.6; \text{ or } 5 \times 0.12 = 0.6.$$

When the rate is ½, ⅓, ¼, ⅕, etc., of 100, that is to say 50, 33⅓, 25, 20, etc., the percentage may be found by taking ½, ⅓, ¼, ⅕ of the number, thus:

50% of $82.00 is ½ of $82 = $41; 33⅓% of $60 is ⅓ of $60 = $20.

To find the rate of percentage, or what per cent one number is of another, multiply the number which is the percentage, by 100, and divide by the other number; the quotient is the rate per cent.

What per cent of 180 is 45? $45 \times 100 \div 180 = 25\%$.

What per cent of $650 is 32.50? $32.50 \times 100 \div 650 = 5\%$.

3,000 lbs. malt give 1,950 lbs. extract. How many per cent of extract is obtained? $1{,}950 \times 100 \div 3{,}000 = 65\%$.

To find a number when a per cent of it is given, divide the number which is the percentage by the given rate per cent and multiply the product by 100.

50 is 25% of what number? $50 \div 25 \times 100 = 200$.

$36.50 is 12½% of what number? $36.5 \div 12.5 \times 100 = \$292.00$.

INTEREST.

"Interest" is money paid for the use of money.

"Principal" is the sum on which interest is paid.

"Rate of Interest" is the per cent of the principal, paid for its use *for one year.*

To find the interest of any sum at any rate per cent,. for years and months: Multiply the principal by the rate, and the product is the interest for one year. Multiply the interest for one year by the time in years, and the fraction of a year; the product is the required interest. Add the principal to the interest for the amount.

Interest of $640 for 5 years and 6 months at 7%.

$$
\begin{array}{rl}
\$640 \times 0.07 = \$44.80 & \text{interest for 1 year.} \\
5\tfrac{1}{2} & \\
\hline
246.40 & \text{Interest for 5 years 6 months.} \\
640.00 & \text{Principal.} \\
\hline
\$886.40 & \text{Amount of principal with interest.}
\end{array}
$$

Six Per Cent Method.—At 6% per annum the interest of $1.00

For 12 mo..................is	6 cents or	0.06	of the	principal.
" 2 mo. or $\frac{1}{6}$ of 12 mo...is	1 "	0.01	"	"
" 1 mo. or $\frac{1}{12}$ of 12 mo..is	$\frac{1}{2}$ "	0.005	"	"
" 6 days or $\frac{1}{5}$ of 1 mo....is	$\frac{1}{10}$ "	0.001	"	"
" 1 day or $\frac{1}{6}$ of 6 days...is	$\frac{1}{60}$ "	$0.00\frac{1}{6}$	"	"

The following table denotes the part of the interest to be added or subtracted to give the interest at the given per cent:

$7\% = 6\% + \frac{1}{6}$ of 6%	$10\% = \frac{1}{6}$ of $6\% \times 10$
$7\frac{1}{2}\% = 6\% + \frac{1}{4}$ of 6%	$5\% = 6\% - \frac{1}{6}$ of 6%
$8\% = 6\% + \frac{1}{3}$ of 6%	$4\% - 6\% - \frac{1}{3}$ of 6%
$9\% = 6\% + \frac{1}{2}$ of 6%	$3\% = 6\% - \frac{1}{2}$ of 6%

To find the principal, when interest, time, and rate are given: Divide the given interest for the given time by the interest of $1.00 for the given time at the given rate.

Interest gained in 2 years at 7% is $84. What is the principal?

At 7% the interest of $1.00 per year = 0.07

At 7% the interest of $1.00 2 years = 0.14

$84 \div 0.14 = \$600.$

RATIO.

"Ratio" is the relation between two numbers, denoting how often one quantity is contained in another. The ratio of 16 to 2 is 16:2 = 8. The sign of ratio is the colon, or sign of division without line, thus:

A "simple ratio" is the ratio of two numbers, as 6:3.

A "compound ratio" is the ratio of the products of the corresponding terms of two or more simple ratios. Thus 2:4, 5:15, 30:3 are simple ratios, $2 \times 5 \times 30 : 4 \times 15 \times 3$ is a compound ratio. When the multiplication is performed the compound ratio passes into a simple ratio—300:180.

EQUATION.

Equation is an expression of equality between two or more numbers. $4 + 6 = 10$; $15 + 5 = 12 + 8$. The numbers to the left of the sign (=) are called the "first member," those at the right of the sign the "second member" of the equation. The numbers of the equation are called "terms."

PROPORTION.

Proportion is an equality of ratios, or an equation in which each member is a ratio. Ratio of 2 to 4 equals ratio of 3 to 6, $\frac{2}{4} = \frac{3}{6}$, expressed thus: $2:4 = 3:6$, reads "2 is to 4 as 3 is to 6." The first and fourth terms are called the extremes, or outer terms, the second and third the means, or inner terms.

The product of the means = product of the extremes.

The product of the extremes divided by either mean will give the other mean, thus $14:7 = 6:3$; $3 \times 14 = 42$; $42 \div 6 = 7$; $42 \div 7 = 6$.

The product of the means divided by either extreme will give the other extreme, thus: $8:4 = 10:5$; $4 \times 10 = 40$; $40 \div 5 = 8$; $40 \div 8 = 5$.

(The sign :: is often used in place of the "equal" mark in proportions, but is not used in this book, as it introduces needless complexity.)

SIMPLE PROPORTIONS.

A simple proportion is an equality between two simple ratios. When three of the terms are given, the fourth can be found. Of the three given members two must be of the same kind, and the third of the same kind at the required term.

The Rule of Three shows how to find the fourth term of a proportion when three terms are given. Of the three quantities given set that down for the third term which is of the same kind as the term required. If the amount to be found will be greater than the third term, make the greater of the two remaining given quantities the *second term,* and the other the first; but if less, *put the less term second* and the greater first. When the thre

terms are so arranged, multiply the second and third together, and divide the product by the first. The first and second term must be reduced to the same denomination.

Example 1.—If 3 tons of coal cost $15 what will 11 tons cost? Here the terms are 3 tons, 11 tons, and $15, and the required term is a certain number of dollars, that is, of the same kind as $15, which is, therefore, set down as the third term. As 11 tons will cost more than 3 tons, the required term is greater than 15; so, take the larger of the remaining terms, or 11 tons, for the second term, and make the proportion thus: 3 tons : 11 tons = 15 : ? The fourth term is 11×15 or $165 \div 3$, or $55.

Example 2.—If 8 bushels of malt give 5.5 barrels of wort, how many barrels will 300 bushels give?

The terms are 8 bushels, 300 bushels, 5.5 barrels and a certain unknown number of barrels which is greater than 5.5 barrels. The third term is, therefore, 5.5 barrels, the second 300 bushels and the first eight bushels. Hence 8 bushels : 300 bushels = 5.5 barrels : ? The fourth term is $300 \times 5.5 \div 8$, or 206.2 barrels.

Example 3.—If 152 lbs. malt give 94 lbs. extract, what will 100 lbs. give?

The terms are 152 lbs. malt, 100 lbs. malt and 94 lbs. extract, and a certain unknown number of lbs. of-extract less than 94. The arrangement is, therefore, 152 lbs. : 100 lbs. = 94 : ? The fourth term is $100 \times 94 \div 152$, or 61.8 lbs. extract.

Example 4.—If 3 tons of coal cost $15, how many tons can be bought for $50?

The terms are $15, $50, and 3 tons, and the proportion is:

$15 : $50 = 3 tons : ? The fourth term is $3 \times 50 \div 15$, or 10 tons.

INVOLUTION.

Involution is the continued multiplication of a number by itself a given number of times. A "power" of a number is the product obtained by this process. Thus 8 is the third power of 2, since $8 = 2 \times 2 \times 2$, and 16 is the second power of 4, since $16 = 4 \times 4$.

The "base" or "root" of a power is a number which multiplied by itself a certain number of times gives the power. Thus 4 is the base or root of 16, since $4 \times 4 = 16$; 3 is the root of 27 since $3 \times 3 \times 3 = 27$.

The "exponent" of a power is a number placed at the right of

[redacted]

the base and a little above it to show how many times the base must be multiplied by itself to produce the power.

Thus 2^1 or 2	is the first power of 2 =	2
2^2 or 2×2	is the second power of 2 =	4
2^3 or $2 \times 2 \times 2$	is the third power of 2 =	8
2^4 or $2 \times 2 \times 2 \times 2$	is the fourth power of 2 =	16

The second power of a number is called the "square" of the number; the third power is called the "cube" of a number. Thus 3^2 or 9 is the square of 3; 2^3 or 8 is the cube of 2.

If two powers of the same number are multiplied, the product is the same as if the number had an exponent equal to the sum of the two exponents. Thus $2^2 \times 2^3 = 2^5$; for $2^2 = 2 \times 2$ and $2^3 = 2 \times 2 \times 2$, hence $2^2 \times 2^3 = 2 \times 2 \times 2 \times 2 \times 2$, or $2^5 = 32$.

For squares and cubes see tables under the respective heads.

EVOLUTION.

Evolution is the finding or extracting the root of any power of a number. The "square root" of a number is that number which, raised to the second power, will give the first number. 3 is the square root of 9 since 3^2 or $3 \times 3 = 9$. The "cube root" of a number is that number which, when raised to the third power, will give the first number. Thus 3 is the cube root of 27, since 3^3 or $3 \times 3 \times 3 = 27$.

The "radical sign" (from radix, Latin for root) is $\sqrt{\ }$; $\sqrt{100}$ denotes the square roots of $100 = 10$; $\sqrt[3]{64}$ denotes the cube root of $64 = 4$; $\sqrt[4]{16}$ denotes fourth root of $16 = 2$. The small index above the radical sign indicates what root is to be found. When no index is written, the index 2, calling for the square root, is understood.

TO FIND ANY ROOT OF A NUMBER BY FACTORING.

1. To find the cube root of 9261.

3	9261
3	3087
3	1029
7	343
7	49
7	7
	1

The prime factors of 9261 are 3, 3, 3, 7, 7, 7; hence $9261 = (3 \times 7) \times (3 \times 7) \times (3 \times 7)$, therefore the cube root of 9261 is 3×7 or 21.

2. To find the square root of 144.

2	144
2	72
2	36
2	18
3	9
3	3
	1

The prime factors of 144 are 2, 2, 2, 2, 3, 3; hence $144 = (2 \times 2 \times 3) \times (2 \times 2 \times 3)$, therefore the square root of 144 is $2 \times 2 \times 3$, or 12.

Rule.—Resolve the given number into its prime factors, then, to produce the square root, take one of every two equal factors; to produce the cube root, take one of every three equal factors.

A perfect square is a number which has an exact square root; such are 4, 9, 16, 25, etc.

GENERAL METHOD OF FINDING THE SQUARE ROOT OF A NUMBER.

Example 1.—To find the square root of 1522756.

Separate the given number into periods of two figures, beginning at the right. The left hand period may contain only one figure. Thus: 1.52.27.56.

Find the greatest number whose square is contained in the period on the left, and this number is the first figure in the root. Subtract the square of this figure from the left period and to the remainder, if any, annex the next period to form a new dividend. The greatest number whose square is contained in 1 is 1 and the square of 1 is 1, subtracting 1 from 1 leaves no remainder and we, therefore, have the next period, or 52, as divided. Thus:

$$
\begin{array}{ll}
1\sqrt{\overline{1.52.27.56}} & (1 \\
\quad 1 & \\
\hline
\quad 52 &
\end{array}
$$

Double the first figure of the root (1) and divide it into the new dividend, omitting the figure on the right (2), the quotient is the second figure of the root. Thus:

$$
\begin{array}{ll}
1\sqrt{\overline{1.52.27.56}} & (12 \\
1 \quad 1 & \\
\hline
2 \mid 52 &
\end{array}
$$

Write the second figure of the root (2) after the new divisor

n multiply this divisor by the last figure of the root, and the product from the dividend (52). Thus:

```
1√1.52.27.56 (12
1  1
--------
   22 | 52
      | 44
        --
         8
```

ɔring down the next period and continue as before. Thus:

```
1√1.52.27.56 (1234 = square root.
1  1
--------
   22 | 52
    2 | 44
----------
  243 | 827
    3 | 729
-----------
 2464 | 9856
      | 9856
```

ple 2.—What is the square root of 204304?

```
4√20.43.04 (452 = square root.
4  16
--------
   85 | 443
    5 | 425
----------
  902 | 1804
      | 1804
```

ple 3.—What is the square root of 498436?

```
7√49.84.36 (706 = square root.
7  49
--------
  140 | 84
    0 | 00
----------
 1406 | 8436
      | 8436
```

umber contains a decimal, begin at the units place and pro- ɩh toward the left and right to separate into periods, then *as in the extraction* of the square root of whole numbers.

Example 1.—What is the square root of 104.2441?

$$
\begin{array}{r|l}
\multicolumn{2}{l}{1\sqrt{1.04.24.41}\ (10.21 = \text{square root.}} \\
\multicolumn{2}{l}{1} \\
\hline
20 & 04 \\
0 & 00 \\
\hline
202 & 424 \\
2 & 404 \\
\hline
2041 & 2041 \\
 & 2041
\end{array}
$$

GENERAL METHOD OF FINDING THE CUBE ROOT OF A NUMBER.

Separate the given number into periods of three figures, beginning at the right for an integer, and going left and right from the decimal point for a decimal fraction. Thus: 12.738,927.

Example 1. What is the cube root of 405,224?

Find the greatest number whose cube is contained in the first period 405. It is 7. Subtract the cube of 7 tens from the given number, the remainder is 62,224. Divide this remainder by three times the square of the tens of the first figure of the root (3×70^2). This will give the quotient 4. $70 + 4$ is the cube root.

$$
\begin{array}{rl}
 & 405{,}224\ (70 + 4 = 74 \\
70^3 = & 343{,}000 \\
\hline
70^2 \times 3 = 14{,}700) & 62{,}224
\end{array}
$$

74 is the cube root.

Example 2.—What is the cube root of 12812904 (abridged form)?

$$
\begin{array}{rr|l}
 & \multicolumn{2}{l}{12{,}812{,}904\ (234} \\
 & 2^3 = & 8 \\
\hline
3 \times 20^2 = & 1200 & 4 \\
3 \times 20 \times 3 = & 180 & \\
3^2 = & 9 & \\
\hline
 & 1389 & 4812 \\
 & & 4167 \\
\hline
3 \times 230^2 = & 158700 & 645 \\
3 \times 230 \times 4 = & 2760 & \\
4^2 = & 16 & \\
\hline
 & 161476 & 645.904 \\
 & & 645.904
\end{array}
$$

Cube root is 234.

SQUARES AND CUBES, SQUARE ROOTS AND CUBE ROOTS FOR 1 TO 1,000.

No.	Square.	Cube.	Sq. Rt.	C. Rt.	No.	Square.	Cube.	Sq. Rt.	C. Rt.
1	1	1	1.0000	1.0000	61	3721	226981	7.8102	3.9365
2	4	8	1.4142	1.2599	62	3844	238328	7.8740	3.9579
3	9	27	1.7321	1.4422	63	3969	250047	7.9373	3.9791
4	16	64	2.0000	1.5874	64	4096	262144	8.0000	4.
5	25	125	2.2361	1.7100	65	4225	274625	8.0623	4.0207
6	36	216	2.4495	1.8171	66	4356	287496	8.1240	4.0412
7	49	343	2.6458	1.9129	67	4489	300763	8.1854	4.0615
8	64	512	2.8284	2.0000	68	4624	314432	8.2462	4.0817
9	81	729	3.0000	2.0801	69	4761	328509	8.3066	4.1016
10	100	1000	3.1623	2.1544	70	4900	343000	8.3666	4.1213
11	121	1331	3.3166	2.2240	71	5041	357911	8.4261	4.1408
12	144	1728	3.4641	2.2894	72	5184	373248	8.4853	4.1602
13	169	2197	3.6056	2.3513	73	5329	389017	8.5440	4.1793
14	196	2744	3.7417	2.4101	74	5476	405224	8.6023	4.1983
15	225	3375	3.8730	2.4662	75	5625	421875	8.6603	4.2172
16	256	4096	4.0000	2.5198	76	5776	438976	8.7178	4.2358
17	289	4913	4.1231	2.5713	77	5929	456533	8.7750	4.2543
18	324	5832	4.2426	2.6207	78	6084	474552	8.8318	4.2727
19	361	6859	4.3589	2.6684	79	6241	493039	8.8882	4.2908
20	400	8000	4.4721	2.7144	80	6400	512000	8.9443	4.3089
21	441	9261	4.5826	2.7589	81	6561	531441	9.	4.3267
22	484	10648	4.6904	2.8020	82	6724	551368	9.0554	4.3445
23	529	12167	4.7958	2.8439	83	6889	571787	9.1104	4.3621
24	576	13824	4.8990	2.8845	84	7056	592704	9.1652	4.3795
25	625	15625	5.0000	2.9240	85	7225	614125	9.2195	4.3968
26	676	17576	5.0990	2.9625	86	7396	636056	9.2736	4.4140
27	729	19683	5.1962	3.0000	87	7569	658503	9.3274	4.4310
28	784	21952	5.2915	3.0366	88	7744	681472	9.3808	4.4480
29	841	24389	5.3852	3.0723	89	7921	704969	9.4340	4.4647
30	900	27000	5.4772	3.1072	90	8100	729000	9.4868	4.4814
31	961	29791	5.5678	3.1414	91	8281	753571	9.5394	4.4979
32	1024	32768	5.6569	3.1748	92	8464	778688	9.5917	4.5144
33	1089	35937	5.7446	3.2075	93	8649	804357	9.6437	4.5307
34	1156	39304	5.8310	3.2396	94	8836	830584	9.6954	4.5468
35	1225	42875	5.9161	3.2711	95	9025	857375	9.7468	4.5629
36	1296	46656	6.0000	3.3019	96	9216	884736	9.7980	4.5789
37	1369	50653	6.0828	3.3322	97	9409	912673	9.8489	4.5947
38	1444	54872	6.1644	3.3620	98	9604	941192	9.8995	4.6104
39	1521	59319	6.2450	3.3912	99	9801	970299	9.9499	4.6261
40	1600	64000	6.3246	3.4200	100	10000	1000000	10.	4.6416
41	1681	68921	6.4031	3.4482	101	10201	1030301	10.0499	4.6570
42	1764	74088	6.4807	3.4760	102	10404	1061208	10.0995	4.6723
43	1849	79507	6.5574	3.5034	103	10609	1092727	10.1489	4.6875
44	1936	85184	6.6332	3.5303	104	10816	1124864	10.1980	4.7027
45	2025	91125	6.7082	3.5569	105	11025	1157625	10.2470	4.7177
46	2116	97336	6.7823	3.5830	106	11236	1191016	10.2956	4.7326
47	2209	103823	6.8557	3.6088	107	11449	1225043	10.3441	4.7475
48	2304	110592	6.9282	3.6342	108	11664	1259712	10.3923	4.7622
49	2401	117649	7.0000	3.6593	109	11881	1295029	10.4403	4.7769
50	2500	125000	7.0711	3.6840	110	12100	1331000	10.4881	4.7914
51	2601	132651	7.1414	3.7084	111	12321	1367631	10.5357	4.8059
52	2704	140608	7.2111	3.7325	112	12544	1404928	10.5830	4.8203
53	2809	148877	7.2801	3.7563	113	12769	1442897	10.6301	4.8346
54	2916	157464	7.3485	3.7798	114	12996	1481544	10.6771	4.8488
55	3025	166375	7.4162	3.8030	115	13225	1520875	10.7238	4.8629
56	3136	175616	7.4833	3.8259	116	13456	1560896	10.7703	4.8770
57	3249	185193	7.5498	3.8485	117	13689	1601613	10.8167	4.8910
58	3364	195112	7.6158	3.8709	118	13924	1643032	10.8628	4.9049
59	3481	205379	7.6811	3.8930	119	14161	1685159	10.9087	4.9187
60	3600	216000	7.7460	3.9149	120	14400	1728000	10.9545	4.9324

No.	Square.	Cube.	Sq. Rt.	C. Rt.	No.	Square.	Cube.	Sq. Rt.	C. Rt.
121	14641	1771561	11.	4.9461	186	34596	6434856	13.6382	5.7083
122	14884	1815848	11.0454	4.9597	187	34969	6539203	13.6748	5.7185
123	15129	1860867	11.0905	4.9732	188	35344	6644672	13.7113	5.7287
124	15376	1906624	11.1355	4.9866	189	35721	6751269	13.7477	5.7388
125	15625	1953125	11.1803	5.	190	36100	6859000	13.7840	5.7489
126	15876	2000376	11.2250	5.0133	191	36481	6967871	13.8203	5.7590
127	16129	2048383	11.2694	5.0265	192	36864	7077888	13.8564	5.7690
128	16384	2097152	11.3137	5.0397	193	37249	7189057	13.8924	5.7790
129	16641	2146689	11.3578	5.0528	194	37636	7301384	13.9284	5.7890
130	16900	2197000	11.4018	5.0658	195	38025	7414875	13.9642	5.7989
131	17161	2248091	11.4455	5.0788	196	38416	7529536	14.	5.8088
132	17424	2299968	11.4891	5.0916	197	38809	7645373	14.0357	5.8186
133	17689	2352637	11.5326	5.1045	198	39204	7762392	14.0712	5.8285
134	17956	2406104	11.5758	5.1172	199	39601	7880599	14.1067	5.8383
135	18225	2460375	11.6190	5.1299	200	40000	8000000	14.1421	5.8480
136	18496	2515456	11.6619	5.1426	201	40401	8120601	14.1774	5.8578
137	18769	2571353	11.7047	5.1551	202	40804	8242408	14.2127	5.8675
138	19044	2628072	11.7473	5.1676	203	41209	8365427	14.2478	5.8771
139	19321	2685619	11.7898	5.1801	204	41616	8489664	14.2829	5.8868
140	19600	2744000	11.8322	5.1925	205	42025	8615125	14.3178	5.8964
141	19881	2803221	11.8743	5.2048	206	42436	8741816	14.3527	5.9059
142	20164	2863288	11.9164	5.2171	207	42849	8869743	14.3875	5.9155
143	20449	2924207	11.9583	5.2293	208	43264	8998912	14.4222	5.9250
144	20736	2985984	12.	5.2415	209	43681	9129329	14.4568	5.9345
145	21025	3048625	12.0416	5.2536	210	44100	9261000	14.4914	5.9439
146	21316	3112136	12.0830	5.2656	211	44521	9393931	14.5258	5.9533
147	21609	3176523	12.1244	5.2776	212	44944	9528128	14.5602	5.9627
148	21904	3241792	12.1655	5.2896	213	45369	9663597	14.5945	5.9721
149	22201	3307949	12.2066	5.3015	214	45796	9800344	14.6287	5.9814
150	22500	3375000	12.2474	5.3133	215	46225	9938375	14.6629	5.9907
151	22801	3442951	12.2882	5.3251	216	46656	10077696	14.6969	6.
152	23104	3511808	12.3288	5.3368	217	47089	10218313	14.7309	6.0092
153	23409	3581577	12.3693	5.3485	218	47524	10360232	14.7648	6.0185
154	23716	3652264	12.4097	5.3601	219	47961	10503459	14.7986	6.0277
155	24025	3723875	12.4499	5.3717	220	48400	10648000	14.8324	6.0368
156	24336	3796416	12.4900	5.3832	221	48841	10793861	14.8661	6.0459
157	24649	3869893	12.5300	5.3947	222	49284	10941048	14.8997	6.0550
158	24964	3944312	12.5698	5.4061	223	49729	11089567	14.9332	6.0641
159	25281	4019679	12.6095	5.4175	224	50176	11239424	14.9666	6.0732
160	25600	4096000	12.6491	5.4288	225	50625	11390625	15.	6.0822
161	25921	4173281	12.6886	5.4401	226	51076	11543176	15.0333	6.0912
162	26244	4251528	12.7279	5.4514	227	51529	11697083	15.0665	6.1002
163	26569	4330747	12.7671	5.4626	228	51984	11852352	15.0997	6.1091
164	26896	4410944	12.8062	5.4737	229	52441	12008989	15.1327	6.1180
165	27225	4492125	12.8452	5.4848	230	52900	12167000	15.1658	6.1269
166	27556	4574296	12.8841	5.4959	231	53361	12326391	15.1987	6.1358
167	27889	4657463	12.9228	5.5069	232	53824	12487168	15.2315	6.1446
168	28224	4741632	12.9615	5.5178	233	54289	12649337	15.2643	6.1534
169	28561	4826809	13.	5.5288	234	54756	12812904	15.2971	6.1622
170	28900	4913000	13.0384	5.5397	235	55225	12977875	15.3297	6.1710
171	29241	5000211	13.0767	5.5505	236	55696	13144256	15.3623	6.1797
172	29584	5088448	13.1149	5.5613	237	56169	13312053	15.3948	6.1885
173	29929	5177717	13.1529	5.5721	238	56644	13481272	15.4272	6.1972
174	30276	5268024	13.1909	5.5828	239	57121	13651919	15.4596	6.2058
175	30625	5359375	13.2288	5.5934	240	57600	13824000	15.4919	6.2145
176	30976	5451776	13.2665	5.6041	241	58081	13997521	15.5242	6.2231
177	31329	5545233	13.3041	5.6147	242	58564	14172488	15.5563	6.2317
178	31684	5639752	13.3417	5.6252	243	59049	14348907	15.5885	6.2403
179	32041	5735339	13.3791	5.6357	244	59536	14526784	15.6205	6.2488
180	32400	5832000	13.4164	5.6462	245	60025	14706125	15.6525	6.2573
181	32761	5929741	13.4536	5.6567	246	60516	14886936	15.6844	6.2658
182	33124	6028568	13.4907	5.6671	247	61009	15069223	15.7162	6.2743
183	33489	6128487	13.5277	5.6774	248	61504	15252992	15.7480	6.2828
184	33856	6229504	13.5647	5.6877	249	62001	15438249	15.7797	6.2912
185	34225	6331625	13.6015	5.6980	250	62500	15625000	15.8114	6.2996

No.	Square.	Cube.	Sq. Rt.	C. Rt	No.	Square.	Cube.	Sq. Rt.	C. Rt.
251	63001	15813251	15.8430	6.3080	316	99856	31554496	17.7764	6.8113
252	63504	16003008	15.8745	6.3164	317	100489	31855013	17.8045	6.8185
253	64009	16194277	15.9060	6.3247	318	101124	32157432	17.8326	6.8256
254	64516	16387064	15.9374	6.3330	319	101761	32461759	17.8606	6.8328
255	65025	16581375	15.9687	6.3413	320	102400	32768000	17.8885	6.8399
256	65536	16777216	16.	6.3496	321	103041	33076161	17.9165	6.8470
257	66049	16974593	16.0312	6.3579	322	103684	33386248	17.9444	6.8541
258	66564	17173512	16.0624	6.3661	323	104329	33698267	17.9722	6.8612
259	67081	17373979	16.0935	6.3743	324	104976	34012224	18.	6.8683
260	67600	17576000	16.1245	6.3825	325	105625	34328125	18.0278	6.8753
261	68121	17779581	16.1555	6.3907	326	106276	34645976	18.0555	6.8824
262	68644	17984728	16.1864	6.3988	327	106929	34965783	18.0831	6.8894
263	69169	18191447	16.2173	6.4070	328	107584	35287552	18.1108	6.8964
264	69696	18399744	16.2481	6.4151	329	108241	35611289	18.1384	6.9034
265	70225	18609625	16.2788	6.4232	330	108900	35937000	18.1659	6.9104
266	70756	18821096	16.3095	6.4312	331	109561	36264691	18.1934	6.9174
267	71289	19034163	16.3401	6.4393	332	110224	36594368	18.2209	6.9244
268	71824	19248832	16.3707	6.4473	333	110889	36926037	18.2483	6.9313
269	72361	19465109	16.4012	6.4553	334	111556	37259704	18.2757	6.9382
270	72900	19683000	16.4317	6.4633	335	112225	37595375	18.3030	6.9451
271	73441	19902511	16.4621	6.4713	336	112896	37933056	18.3303	6.9521
272	73984	20123648	16.4924	6.4792	337	113569	38272753	18.3576	6.9589
273	74529	20346417	16.5227	6.4872	338	114244	38614472	18.3848	6.9658
274	75076	20570824	16.5529	6.4951	339	114921	38958219	18.4120	6.9727
275	75625	20796875	16.5831	6.5030	340	115600	39304000	18.4391	6.9795
276	76176	21024576	16.6132	6.5108	341	116281	39651821	18.4662	6.9864
277	76729	21253933	16.6433	6.5187	342	116964	40001688	18.4932	6.9932
278	77284	21484952	16.6733	6.5265	343	117649	40353607	18.5203	7.
279	77841	21717639	16.7033	6.5343	344	118336	40707584	18.5472	7.0068
280	78400	21952000	16.7332	6.5421	345	119025	41063625	18.5742	7.0136
281	78961	22188041	16.7631	6.5499	346	119716	41421736	18.6011	7.0203
282	79524	22425768	16.7929	6.5577	347	120409	41781923	18.6279	7.0271
283	80089	22665187	16.8226	6.5654	348	121104	42144192	18.6548	7.0338
284	80656	22906304	16.8523	6.5731	349	121801	42508549	18.6815	7.0406
285	81225	23149125	16.8819	6.5808	350	122500	42875000	18.7083	7.0473
286	81796	23393656	16.9115	6.5885	351	123201	43243551	18.7350	7.0540
287	82369	23639903	16.9411	6.5962	352	123904	43614208	18.7617	7.0607
288	82944	23887872	16.9706	6.6039	353	124609	43986977	18.7883	7.0674
289	83521	24137569	17.	6.6115	354	125316	44361864	18.8149	7.0740
290	84100	24389000	17.0294	6.6191	355	126025	44738875	18.8414	7.0807
291	84681	24642171	17.0587	6.6267	356	126736	45118016	18.8680	7.0873
292	85264	24897088	17.0880	6.6343	357	127449	45499293	18.8944	7.0940
293	85849	25153757	17.1172	6.6419	358	128164	45882712	18.9209	7.1006
294	86436	25412184	17.1464	6.6494	359	128881	46268279	18.9473	7.1072
295	87025	25672375	17.1756	6.6569	360	129600	46656000	18.9737	7.1138
296	87616	25934336	17.2047	6.6644	361	130321	47045881	19.	7.1204
297	88209	26198073	17.2337	6.6719	362	131044	47437928	19.0263	7.1269
298	88804	26463592	17.2627	6.6794	363	131769	47832147	19.0526	7.1335
299	89401	26730899	17.2916	6.6869	364	132496	48228544	19.0788	7.1400
300	90000	27000000	17.3205	6.6943	365	133225	48627125	19.1050	7.1466
301	90601	27270901	17.3494	6.7018	366	133956	49027896	19.1311	7.1531
302	91204	27543608	17.3781	6.7092	367	134689	49430863	19.1572	7.1596
303	91809	27818127	17.4069	6.7166	368	135424	49836032	19.1833	7.1661
304	92416	28094464	17.4356	6.7240	369	136161	50243409	19.2094	7.1726
305	93025	28372625	17.4642	6.7313	370	136900	50653000	19.2354	7.1791
306	93636	28652616	17.4929	6.7387	371	137641	51064811	19.2614	7.1855
307	94249	28934443	17.5214	6.7460	372	138384	51478848	19.2873	7.1920
308	94864	29218112	17.5499	6.7533	373	139129	51895117	19.3132	7.1984
309	95481	29503629	17.5784	6.7606	374	139876	52313624	19.3391	7.2048
310	96100	29791000	17.6068	6.7679	375	140625	52734375	19.3649	7.2112
311	96721	30080231	17.6352	6.7752	376	141376	53157376	19.3907	7.2177
312	97344	30371328	17.6635	6.7824	377	142129	53582633	19.4165	7.2240
313	97969	30664297	17.6918	6.7897	378	142884	54010152	19.4422	7.2304
314	98596	30959144	17.7200	6.7969	379	143641	54439939	19.4679	7.2368
315	99225	31255875	17.7482	6.8041	380	144400	54872000	19.4936	7.2432

No.	Square.	Cube.	Sq. Rt.	C. Rt.	No.	Square.	Cube.	Sq. Rt.	C. Rt.
641	410881	263374721	25.3180	8.6223	706	498436	351895816	26.5707	8.9043
642	412164	264609288	25.3377	8.6267	707	499849	353393243	26.5895	8.9085
643	413449	265847707	25.3574	8.6312	708	501264	354894912	26.6083	8.9127
644	414736	267089984	25.3772	8.6357	709	502681	356400829	26.6271	8.9169
645	416025	268336125	25.3969	8.6401	710	504100	357911000	26.6458	8.9211
646	417316	269586136	25.4165	8.6446	711	505521	359425431	26.6646	8.9253
647	418609	270840023	25.4362	8.6490	712	506944	360944128	26.6833	8.9295
648	419904	272097792	25.4558	8.6535	713	508369	362467097	26.7021	8.9337
649	421201	273359449	25.4755	8.6579	714	509796	363994344	26.7208	8.9378
650	422500	274625000	25.4951	8.6624	715	511225	365525875	26.7395	8.9420
651	423801	275894451	25.5147	8.6668	716	512656	367061696	26.7582	8.9462
652	425104	277167808	25.5343	8.6713	717	514089	368601813	26.7769	8.9503
653	426409	278445077	25.5539	8.6757	718	515524	370146232	26.7955	8.9545
654	427716	279726264	25.5734	8.6801	719	516961	371694959	26.8142	8.9587
655	429025	281011375	25.5930	8.6845	720	518400	373248000	26.8328	8.9628
656	430336	282300416	25.6125	8.6890	721	519841	374805361	26.8514	8.9670
657	431649	283593393	25.6320	8.6934	722	521284	376367048	26.8701	8.9711
658	432964	284890312	25.6515	8.6978	723	522729	377933067	26.8887	8.9752
659	434281	286191179	25.6710	8.7022	724	524176	379503424	26.9072	8.9794
660	435600	287496000	25.6905	8.7066	725	525625	381078125	26.9258	8.9835
661	436921	288804781	25.7099	8.7110	726	527076	382657176	26.9444	8.9876
662	438244	290117528	25.7294	8.7154	727	528529	384240583	26.9629	8.9918
663	439569	291434247	25.7488	8.7198	728	529984	385828352	26.9815	8.9959
664	440896	292754944	25.7682	8.7241	729	531441	387420489	27.	9.
665	442225	294079625	25.7876	8.7285	730	532900	389017000	27.0185	9.0041
666	443556	295408296	25.8070	8.7329	731	534361	390617891	27.0370	9.0082
667	444889	296740963	25.8263	8.7373	732	535824	392223168	27.0555	9.0123
668	446224	298077632	25.8457	8.7416	733	537289	393832837	27.0740	9.0164
669	447561	299418309	25.8650	8.7460	734	538756	395446904	27.0924	9.0205
670	448900	300763000	25.8844	8.7503	735	540225	397065375	27.1109	9.0246
671	450241	302111711	25.9037	8.7547	736	541696	398688256	27.1293	9.0287
672	451584	303464448	25.9230	8.7590	737	543169	400315553	27.1477	9.0328
673	452929	304821217	25.9422	8.7634	738	544644	401947272	27.1662	9.0369
674	454276	306182024	25.9615	8.7677	739	546121	403583419	27.1846	9.0410
675	455625	307546875	25.9808	8.7721	740	547600	405224000	27.2029	9.0450
676	456976	308915776	26.	8.7764	741	549081	406869021	27.2213	9.0491
677	458329	310288733	26.0192	8.7807	742	550564	408518488	27.2397	9.0532
678	459684	311665752	26.0384	8.7850	743	552049	410172407	27.2580	9.0572
679	461041	313046839	26.0576	8.7893	744	553536	411830784	27.2764	9.0613
680	462400	314432000	26.0768	8.7937	745	555025	413493625	27.2947	9.0654
681	463761	315821241	26.0960	8.7980	746	556516	415160936	27.3130	9.0694
682	465124	317214568	26.1151	8.8023	747	558009	416832723	27.3313	9.0735
683	466489	318611987	26.1343	8.8066	748	559504	418508992	27.3496	9.0775
684	467856	320013504	26.1534	8.8109	749	561001	420189749	27.3679	9.0816
685	469225	321419125	26.1725	8.8152	750	562500	421875000	27.3861	9.0856
686	470596	322828856	26.1916	8.8194	751	564001	423564751	27.4044	9.0896
687	471969	324242703	26.2107	8.8237	752	565504	425259008	27.4226	9.0937
688	473344	325660672	26.2298	8.8280	753	567009	426957777	27.4408	9.0977
689	474721	327082769	26.2488	8.8323	754	568516	428661064	27.4591	9.1017
690	476100	328509000	26.2679	8.8366	755	570025	430368875	27.4773	9.1057
691	477481	329939371	26.2869	8.8408	756	571536	432081216	27.4955	9.1098
692	478864	331373888	26.3059	8.8451	757	573049	433798093	27.5136	9.1138
693	480249	332812557	26.3249	8.8493	758	574564	435519512	27.5318	9.1178
694	481636	334255384	26.3439	8.8536	759	576081	437245479	27.5500	9.1218
695	483025	335702375	26.3629	8.8578	760	577600	438976000	27.5681	9.1258
696	484416	337153536	26.3818	8.8621	761	579121	440711081	27.5862	9.1298
697	485809	338608873	26.4008	8.8663	762	580644	442450728	27.6043	9.1338
698	487204	340068392	26.4197	8.8706	763	582169	444194947	27.6225	9.1378
699	488601	341532099	26.4386	8.8748	764	583696	445943744	27.6405	9.1418
700	490000	343000000	26.4575	8.8790	765	585225	447697125	27.6586	9.1458
701	491401	344472101	26.4764	8.8833	766	586756	449455096	27.6767	9.1498
702	492804	345948408	26.4953	8.8875	767	588289	451217663	27.6948	9.1537
703	494209	347428927	26.5141	8.8917	768	589824	452984832	27.7128	9.1577
704	495616	348913664	26.5330	8.8959	769	591361	454756609	27.7308	9.1617
705	497025	350402625	26.5518	8.9001	770	592900	456533000	27.7489	9.1657

No.	Square.	Cube.	Sq. Rt.	C. Rt.	No.	Square.	Cube.	Sq. Rt.	C. Rt.
771	594441	458314011	27.7669	9.1696	836	698896	584277056	28.9137	9.4204
772	595984	460099648	27.7849	9.1736	837	700569	586376253	28.9310	9.4241
773	597529	461889917	27.8029	9.1775	838	702244	588480472	28.9482	9.4279
774	599076	463684824	27.8209	9.1815	839	703921	590589719	28.9655	9.4316
775	600625	465484375	27.8388	9.1855	840	705600	592704000	28.9828	9.4354
776	602176	467288576	27.8568	9.1894	841	707281	594823321	29.	9.4391
777	603729	469097433	27.8747	9.1933	842	708964	596947688	29.0172	9.4429
778	605284	470910952	27.8927	9.1973	843	710649	599077107	29.0345	9.4466
779	606841	472729139	27.9106	9.2012	844	712336	601211584	29.0517	9.4503
780	608400	474552000	27.9285	9.2052	845	714025	603351125	29.0689	9.4541
781	609961	476379541	27.9464	9.2091	846	715716	605495736	29.0861	9.4578
782	611524	478211768	27.9643	9.2130	847	717409	607645423	29.1033	9.4615
783	613089	480048687	27.9821	9.2170	848	719104	609800192	29.1204	9.4652
784	614656	481890304	28.	9.2209	849	720801	611960049	29.1376	9.4690
785	616225	483736625	28.0179	9.2248	850	722500	614125000	29.1548	9.4727
786	617796	485587656	28.0357	9.2287	851	724201	616295051	29.1719	9.4764
787	619369	487443403	28.0535	9.2326	852	725904	618470208	29.1890	9.4801
788	620944	489303872	28.0713	9.2365	853	727609	620650477	29.2062	9.4838
789	622521	491169069	28.0891	9.2404	854	729316	622835864	29.2233	9.4875
790	624100	493039000	28.1069	9.2443	855	731025	625026375	29.2404	9.4912
791	625681	494913671	28.1247	9.2482	856	732736	627222016	29.2575	9.4949
792	627264	496793088	28.1425	9.2521	857	734449	629422793	29.2746	9.4986
793	628849	498677257	28.1603	9.2560	858	736164	631628712	29.2916	9.5023
794	630436	500566184	28.1780	9.2599	859	737881	633839779	29.3087	9.5060
795	632025	502459875	28.1957	9.2638	860	739600	636056000	29.3258	9.5097
796	633616	504358336	28.2135	9.2677	861	741321	638277381	29.3428	9.5134
797	635209	506261573	28.2312	9.2716	862	743044	640503928	29.3598	9.5171
798	636804	508169592	28.2489	9.2754	863	744769	642735647	29.3769	9.5207
799	638401	510082399	28.2666	9.2793	864	746496	644972544	29.3939	9.5244
800	640000	512000000	28.2843	9.2832	865	748225	647214625	29.4109	9.5281
801	641601	513922401	28.3019	9.2870	866	749956	649461896	29.4279	9.5317
802	643204	515849608	28.3196	9.2909	867	751689	651714363	29.4449	9.5354
803	644809	517781627	28.3373	9.2948	868	753424	653972032	29.4618	9.5391
804	646416	519718464	28.3549	9.2986	869	755161	656234909	29.4788	9.5427
805	648025	521660125	28.3725	9.3025	870	756900	658503000	29.4958	9.5464
806	649636	523606616	28.3901	9.3063	871	758641	660776311	29.5127	9.5501
807	651249	525557943	28.4077	9.3102	872	760384	663054848	29.5296	9.5537
808	652864	527514112	28.4253	9.3140	873	762129	665338617	29.5466	9.5574
809	654481	529475129	28.4429	9.3179	874	763876	667627624	29.5635	9.5610
810	656100	531441000	28.4605	9.3217	875	765625	669921875	29.5804	9.5647
811	657721	533411731	28.4781	9.3255	876	767376	672221376	29.5973	9.5683
812	659344	535387328	28.4956	9.3294	877	769129	674526133	29.6142	9.5719
813	660969	537367797	28.5132	9.3332	878	770884	676836152	29.6311	9.5756
814	662596	539353144	28.5307	9.3370	879	772641	679151439	29.6479	9.5792
815	664225	541343375	28.5482	9.3408	880	774400	681472000	29.6648	9.5828
816	665856	543338496	28.5657	9.3447	881	776161	683797841	29.6816	9.5865
817	667489	545338513	28.5832	9.3485	882	777924	686128968	29.6985	9.5901
818	669124	547343432	28.6007	9.3523	883	779689	688465387	29.7153	9.5937
819	670761	549353259	28.6182	9.3561	884	781456	690807104	29.7321	9.5973
820	672400	551368000	28.6356	9.3599	885	783225	693154125	29.7489	9.6010
821	674041	553387661	28.6531	9.3637	886	784996	695506456	29.7658	9.6046
822	675684	555412248	28.6705	9.3675	887	786769	697864103	29.7825	9.6082
823	677329	557441767	28.6880	9.3713	888	788544	700227072	29.7993	9.6118
824	678976	559476224	28.7054	9.3751	889	790321	702595369	29.8161	9.6154
825	680625	561515625	28.7228	9.3789	890	792100	704969000	29.8329	9.6190
826	682276	563559976	28.7402	9.3827	891	793881	707347971	29.8496	9.6226
827	683929	565609283	28.7576	9.3865	892	795664	709732288	29.8664	9.6262
828	685584	567663552	28.7750	9.3902	893	797449	712121957	29.8831	9.6298
829	687241	569722789	28.7924	9.3940	894	799236	714516984	29.8998	9.6334
830	688900	571787000	28.8097	9.3978	895	801025	716917375	29.9166	9.6370
831	690561	573856191	28.8271	9.4016	896	802816	719323136	29.9333	9.6406
832	692224	575930368	28.8444	9.4053	897	804609	721734273	29.9500	9.6442
833	693889	578009537	28.8617	9.4091	898	806404	724150792	29.9666	9.6477
834	695556	580093704	28.8791	9.4129	899	808201	726572699	29.9833	9.6513
835	697225	582182875	28.8964	9.4166	900	810000	729000000	30.	9.6549

No.	Square.	Cube.	Sq. Rt.	C. Rt.	No.	Square.	Cube.	Sq. Rt.	C. Rt.
901	811801	731432701	30.0167	9.6585	951	904401	860085351	30.8383	9.8339
902	813604	733870808	30.0333	9.6620	952	906304	862801408	30.8545	9.8374
903	815409	736314327	30.0500	9.6656	953	908209	865523177	30.8707	9.8408
904	817216	738763264	30.0666	9.6692	954	910116	868250664	30.8869	9.8443
905	819025	741217625	30.0832	9.6727	955	912025	870983875	30.9031	9.8477
906	820836	743677416	30.0998	9.6763	956	913936	873722816	30.9192	9.8511
907	822649	746142643	30.1164	9.6799	957	915849	876467493	30.9354	9.8546
908	824464	748613312	30.1330	9.6834	958	917764	879217912	30.9516	9.8580
909	826281	751089429	30.1496	9.6870	959	919681	881974079	30.9677	9.8614
910	828100	753571000	30.1662	9.6905	960	921600	884736000	30.9839	9.8648
911	829921	756058031	30.1828	9.6941	961	923521	887503681	31.	9.8683
912	831744	758550528	30.1993	9.6976	962	925444	890277128	31.0161	9.8717
913	833569	761048497	30.2159	9.7012	963	927369	893056347	31.0322	9.8751
914	835396	763551944	30.2324	9.7047	964	929296	895841344	31.0483	9.8785
915	837225	766060875	30.2490	9.7082	965	931225	898632125	31.0644	9.8819
916	839056	768575296	30.2655	9.7118	966	933156	901428696	31.0805	9.8854
917	840889	771095213	30.2820	9.7153	967	935089	904231063	31.0966	9.8888
918	842724	773620632	30.2985	9.7188	968	937024	907039232	31.1127	9.8922
919	844561	776151559	30.3150	9.7224	969	938961	909853209	31.1288	9.8956
920	846400	778688000	30.3315	9.7259	970	940900	912673000	31.1448	9.8990
921	848241	781229961	30.3480	9.7294	971	942841	915498611	31.1609	9.9024
922	850084	783777448	30.3645	9.7329	972	944784	918330048	31.1769	9.9058
923	851929	786330467	30.3809	9.7364	973	946729	921167317	31.1929	9.9092
924	853776	788889024	30.3974	9.7400	974	948676	924010424	31.2090	9.9126
925	855625	791453125	30.4138	9.7435	975	950625	926859375	31.2250	9.9160
926	857476	794022776	30.4302	9.7470	976	952576	929714176	31.2410	9.9194
927	859329	796597983	30.4467	9.7505	977	954529	932574833	31.2570	9.9227
928	861184	799178752	30.4631	9.7540	978	956484	935441352	31.2730	9.9261
929	863041	801765089	30.4795	9.7575	979	958441	938313739	31.2890	9.9295
930	864900	804357000	30.4959	9.7610	980	960400	941192000	31.3050	9.9329
931	866761	806954491	30.5123	9.7645	981	962361	944076141	31.3209	9.9363
932	868624	809557568	30.5287	9.7680	982	964324	946966168	31.3369	9.9396
933	870489	812166237	30.5450	9.7715	983	966289	949862087	31.3528	9.9430
934	872356	814780504	30.5614	9.7750	984	968256	952763904	31.3688	9.9464
935	874225	817400375	30.5778	9.7785	985	970225	955671625	31.3847	9.9497
936	876096	820025856	30.5941	9.7819	986	972196	958585256	31.4006	9.9531
937	877969	822656953	30.6105	9.7854	987	974169	961504803	31.4166	9.9565
938	879844	825293672	30.6268	9.7889	988	976144	964430272	31.4325	9.9598
939	881721	827936019	30.6431	9.7924	989	978121	967361669	31.4484	9.9632
940	883600	830584000	30.6594	9.7959	990	980100	970299000	31.4643	9.9666
941	885481	833237621	30.6757	9.7993	991	982081	973242271	31.4802	9.9699
942	887364	835896888	30.6920	9.8028	992	984064	976191488	31.4960	9.9733
943	889249	838561807	30.7083	9.8063	993	986049	979146657	31.5119	9.9766
944	891136	841232384	30.7246	9.8097	994	988036	982107784	31.5278	9.9800
945	893025	843908625	30.7409	9.8132	995	990025	985074875	31.5436	9.9833
946	894916	846590536	30.7571	9.8167	996	992016	988047936	31.5595	9.9866
947	896809	849278123	30.7734	9.8201	997	994009	991026973	31.5753	9.9900
948	898704	851971392	30.7896	9.8236	998	996004	994011992	31.5911	9.9933
949	900601	854670349	30.8058	9.8270	999	998001	997002999	31.6070	9.9967
950	902500	857375000	30.8221	9.8305	1000	1000000	1000000000	31.6228	10.

TO EXTRACT A HIGHER ROOT THAN THE CUBE.

The fourth root is the square root of the square root. The sixth root is the cube root of the square root or the square root of the cube root.

For square roots and cube roots see tables under their respective heads.

Other roots are most conveniently found by the use of *logarithms.*

ALLIGATION.

Alligation shows the value of a mixture of different ingredients when the quantity and value of each ingredient is known.

Example.—What is the value of 100 lbs. of a mixture of 200 lbs. of hops at 15 cents a pound, and 100 lbs. of hops at 21 cents a pound?

$200 \times 15 = 3000$
$100 \times 21 = 2100$

300 lbs. 5100 c.

Therefore $5100 \div 300 = 17.0$ cents per lb., or $17.00 per 100 lbs.

ARITHMETICAL PROGRESSION.

Arithmetical progression in a series of numbers is a progressive increase or decrease in each successive number by the addition or subtraction of the same amount at each step; as 1, 2, 3, 4, 5, etc., where 1 is added at each step, or 16, 14, 12, 10, etc, where 2 is subtracted at each step. The numbers in such a series are called its "terms," and the equal increase or decrease the "(common) difference."

The general formula for working an arithmetical progression is:

To find the common difference, knowing the first and last terms and the number of terms: Find the difference between the first and last terms and divide by the number of terms less 1.

To find the last term, knowing the first term, the common difference, and the number of terms: Multiply the number of terms less 1 by the common difference, and to the product add the first term.

To find the number of terms, having the first and the last ones, and the common differences: Take the difference between the first and the last terms, divide by the common difference and add 1.

To find the sum of all the terms, having the first and the last ones, and the number of terms: Add together the first and the last terms, divide by 2 and multiply the quotient by the number of terms.

GEOMETRICAL PROGRESSION.

Geometrical progression in a series of numbers is a progressive increase or decrease in each successive number by multiplication or division by the same multiplier or divisor at each step; as 2, 4, 8, 16, 32, 64, etc., where each succeeding term is produced by multiplying the preceding one by 2; or 80, 40, 20, 10, 5, where each suc-

ceeding term is found by dividing the preceding one by 2. The common multiplier or divisor is called the "(common) ratio."

To find the last term, knowing the first one, the ratio and the number of terms: Raise the ratio to a power 1 less than the number of terms, and multiply by the first term.

To find the sum of all the terms, knowing the first one, the ratio and the number of terms: Raise the ratio to a power equal to the whole number of terms, subtract 1, divide the remainder by the ratio less 1, multiply the quotient by the first term.

LOGARITHMS.

The logarithm of a number is the exponent of the power to which it is necessary to raise a fixed number to produce the given number. This fixed number or "base" in the common logarithms is 10, in the "Naperian" or *"hyperbolic"* 2.718281828. . . . The abbreviation is *"log."*

Logarithms are employed to facilitate numerical calculation, substituting the simpler operations for the more complex, as addition for multiplication, subtraction for division, multiplication for involution, division for evolution. They are peculiarly convenient in computing powers or roots higher than the third or cube.

The logarithm of 1 is 0 in any system; the logarithm of the base is 1. In a system where the base is greater than 1, the logarithms of all numbers above 1 are positive, those below 1 are negative.

The unit or integral part of a logarithm is called the "index" or "characteristic," the decimal part the "mantissa."

In the usual tables of common logarithms only the mantissa is given, with the decimal point in front omitted. To find the index take the number of digits to the left of the decimal point less 1. From 0 to 10 it is 0, from 10 to 99 it is 1, from 100 to 999 it is 2, etc.

The index of the logarithm of a decimal fraction is a negative number and is equal to the number of places which the first figure of the decimal other than 0 is removed from the decimal point. Index of log. 0.005 $= -3$ or $\bar{3}$. the minus sign being often placed above the figure. The mantissa is always positive, even though the index be negative.

The "difference" is the tabular difference between the two nearest logarithms.

[redacted]

The "proportional part" is the difference between the given and the nearest smaller tabular logarithm.

RULES FOR USING TABLE OF LOGARITHMS.

To find the logarithm of a whole number.

For 1 to 100 inclusive. The complete logarithm is given in the table.

For 101-999. Find given number in first column of table. Take decimal part of logarithm from column under 0, including the two figures to the left of it, making six figures; prefix the index 2.

For 1000-9999. Find the three left-hand or first figures of the given number in No. column and take decimals from the column under the fourth figure of the given number (including the two figures to the left of the 0 column); prefix the index 3.

For numbers consisting of five digits or more. Find the logarithm for the number composed of the first four figures, as above; take tabular difference from last column and multiply it by the fifth; fifth and sixth; fifth, sixth and seventh, etc., whatever the excess may be over four figures; from the product reject as many figures, beginning from the right hand, as the excess over four is in the given number, one for five figures, two for six, etc.; add the remaining figures to the logarithm for the first four figures, beginning at the right hand.

For a mixed number: Find logarithm as if it were an integer or whole number and prefix the index of the integral part of the number.

For a decimal fraction: Find logarithm as if the figures were all integers, and prefix index according to rule.

For a vulgar fraction: Reduce to decimal fraction and proceed as for the latter. Or, subtract logarithm of denominator from that of numerator, the difference being the required logarithm.

To find the number where the logarithm is known: First, where the given logarithm is contained in the table: Find first two decimal figures of logarithm in column of two figures to left of 0 column and the other figures in the columns to the right. The first three figures of the number will be found in No. column, the fourth at head of column in which the decimals of the logarithm were found. Point off decimals or prefix ciphers according to the index.

Second, where the given logarithm is not contained in the ta-

ble: Find the next smaller logarithm in the table, and take the number for it, which will give the first four figures of the required number. Subtract the same logarithm from the given one, add ciphers according to the number of places wanted, and divide by the difference found in last column, opposite the logarithm used. Annex quotient to the four figures first obtained and place decimal point, allowing one figure in excess of the index to the left of the decimal point.

COMPUTATION BY MEANS OF LOGARITHMS.

To multiply two numbers, add the logarithms of the numbers, and the sum will be the logarithm of the required number.

To divide two numbers subtract logarithm of divisor from that of dividend, the remainder will be the logarithm of the required number.

To raise a number to a given power, multiply the logarithm of the number by the exponent of the power; the product will be the logarithm of the required number.

To find any root of a given number, divide the logarithm of the number by the index of the root; the quotient will be the logarithm of the root.

To find the fourth term of a proportion, add the logarithms of the second and third terms and subtract the logarithm of the first.

TABLES OF COMMON LOGARITHMS (1 TO 10,000).

1	0	26	1.414 973	51	1.707 57	76	1.880 814
2	.301 03	27	1.431 364	52	1.716 003	77	1.886 491
3	.477 121	28	1.447 158	53	1.724 276	78	1.892 095
4	.602 06	29	1.462 398	54	1 732 394	79	1.897 627
5	.698 97	30	1.477 121	55	1 740 363	80	1.903 09
6	.778 151	31	1.491 362	56	1 748 188	81	1.908 485
7	.845 098	32	1.505 15	57	1.755 875	82	1.913 814
8	.903 09	33	1.518 514	58	1.763 428	83	1.919 078
9	.954 243	34	1 531 479	59	1 770 852	84	1.924 279
10	1	35	1 544 068	60	1.778 151	85	1.929 419
11	1.041 393	36	1.556 303	61	1.785 33	86	1.934 498
12	1.079 181	37	1.568 202	62	1.792 392	87	1.939 519
13	1.113 943	38	1.579 784	63	1 799 341	88	1.944 483
14	1.146 128	39	1.591 065	64	1.806 18	89	1.949 39
15	1.176 091	40	1.602 06	65	1.812 913	90	1.954 243
16	1.204 12	41	1.612 784	66	1.819 544	91	1.959 041
17	1.230 449	42	1.623 249	67	1.826 075	92	1.963 788
18	1.255 273	43	1.633 468	68	1.832 509	93	1.968 483
19	1.278 754	44	1.643 453	69	1.838 849	94	1.973 128
20	1.301 03	45	1.653 213	70	1.845 098	95	1.977 724
21	1.322 219	46	1.662 758	71	1.851 258	96	1.982 271
22	1.342 423	47	1.672 098	72	1.857 332	97	1.986 772
23	1.361 728	48	1.681 241	73	1.863 323	98	1.991 226
24	1.380 211	49	1.690 196	74	1.869 232	99	1.995 635
25	1.397 94	50	1.698 97	75	1.875 061	100	2

No.		0	1	2	3	4	5	6	7	8	9	D
100	00-	0000	0434	0868	1301	1734	2166	2598	3029	3461	3891	432
101	00-	4321	4751	5181	5609	6038	6466	6894	7321	7748	8174	428
102	00-	86	9026	9451	9876	—	—	—	—	—	—	425
102	01-	—	—	—	—	03	0724	1147	157	1993	2415	424
103	01-	2837	3259	368	41	4521	494	536	5779	6197	6616	420
104	01-	7033	7451	7868	8284	87	9116	9532	9947	—	—	417
104	02-	—	—	—	—	—	—	—	—	0361	0775	416
105	02-	1189	1603	2016	2428	2841	3252	3664	4075	4486	4896	412
106	02-	5306	5715	6125	6533	6942	735	7757	8164	8571	8978	408
107	02-	9384	9789	—	—	—	—	—	—	—	—	405
107	03-	—	—	0195	06	1004	1408	1812	2216	2619	3021	404
108	03-	3424	3826	4227	4628	5029	543	583	623	6629	7028	400
109	03-	7426	7825	8223	862	9017	9414	9811	—	—	—	398
109	04-	—	—	—	—	—	—	—	0207	0602	0998	397
110	04-	1393	1787	2182	2576	2969	3362	3755	4148	454	4932	393
111	04-	5323	5714	6105	6495	6885	7275	7664	8053	8442	883	389
112	04-	9218	9606	9993	—	—	—	—	—	—	—	388
112	05-	—	—	—	038	0766	1153	1538	1924	2309	2694	386
113	05-	3078	3463	3846	423	4613	4996	5378	576	6142	6524	383
114	05-	6905	7286	7666	8046	8426	8805	9185	9563	9942	—	383
114	06-	—	—	—	—	—	—	—	—	—	032	379
No.		0	1	2	3	4	5	6	7	8	9	D

No.		0	1	2	3	4	5	6	7	8	9	D
115	06-	0698	1075	1452	1829	2206	2582	2958	3333	3709	4083	376
116	06-	4458	4832	5206	558	5953	6326	6699	7071	7443	[illegible]	373
117	06-	8186	8557	8928	9298	9668	—	—	—	—	—	[illegible]
117	07-	—	—	—	—	—	0038	0407	0776	1145	1514	370
118	07-	1882	225	2617	2985	3352	3718	4085	4451	4816	5182	366
119	07-	5547	5912	6276	664	7004	7368	7731	8094	8457	8819	363
120	07-	9181	9543	9904	—	—	—	—	—	—	—	362
120	08-	—	—	—	0266	0626	0987	1347	1707	2067	2426	360
121	08-	2785	3144	3503	3861	4219	4576	4934	5291	5647	6004	357
122	98-	636	6716	7071	7426	7781	8136	849	8845	9198	9552	355
123	08-	9905	—	—	—	—	—	—	—	—	—	355
123	09-	—	0258	0611	0963	1315	1667	2018	237	2721	3071	353
124	09-	3422	3772	4122	4471	482	5169	5518	5866	6215	6562	349
125	09-	691	7257	7604	7951	8298	8644	899	9335	9681	—	348
125	10-	—	—	—	—	—	—	—	—	—	0026	346
126	10-	0371	0715	1059	1403	1747	2091	2434	2777	3119	3462	343
127	10-	3804	4146	4487	4828	5169	551	5851	6191	6531	6871	341
128	10-	721	7549	7888	8227	8565	8903	9241	9579	9916	—	338
128	11-	—	—	—	—	—	—	—	—	—	0253	337
129	11-	059	0926	1263	1599	1934	227	2605	294	3275	3609	335
130	11-	3943	4277	4611	4944	5278	5611	5943	6276	6608	694	333
131	11-	7271	7603	7934	8265	8595	8926	9256	9586	9915	—	331
131	12-	—	—	—	—	—	—	—	—	—	0245	330
132	12-	0574	0903	1231	156	1888	2216	2544	2871	3198	3525	328
133	12-	3852	4178	4504	483	5156	5481	5806	6131	6456	6781	325
134	12-	7105	7429	7753	8076	8399	8722	9045	9368	969	—	323
134	13-	—	—	—	—	—	—	—	—	—	0012	323
135	13-	0334	0655	0977	1298	1619	1939	226	258	29	3219	321
136	13-	3539	3858	4177	4496	4814	5133	5451	5769	6086	6403	318
137	13-	6721	7037	7354	7671	7987	8303	8618	8934	9249	9564	316
138	13-	9879	—	—	—	—	—	—	—	—	—	315
138	14-	—	0194	0508	0822	1136	145	1763	2076	2389	2702	314
139	14-	3015	3327	3639	3951	4263	4574	4885	5196	5507	5818	311
140	14-	6128	6438	6748	7058	7367	7676	7985	8294	8603	8911	309
141	14-	9219	9527	9835	—	—	—	—	—	—	—	308
141	15-	—	—	—	0142	0449	0756	1063	137	1676	1982	307
142	15-	2288	2594	29	3205	351	3815	412	4424	4728	5032	305
143	15-	5336	564	5943	6246	6549	6852	7154	7457	7759	8061	303
144	15-	8362	8664	8965	9266	9567	9868	—	—	—	—	302
144	16-	—	—	—	—	—	—	0168	0469	0769	1068	301
145	16-	1368	1667	1967	2266	2564	2863	3161	346	3758	4055	299
146	16-	4353	465	4947	5244	5541	5838	6134	643	6726	7022	297
147	16-	7317	7613	7908	8203	8497	8792	9086	938	9674	9968	295
148	17-	0262	0555	0848	1141	1434	1726	2019	2311	2603	2895	293
149	17-	3186	3478	3769	406	4351	4641	4932	5222	5512	5802	291
150	17-	6091	6381	667	6959	7248	7536	7825	8113	8401	8689	289
151	17-	8977	9264	9552	9839	—	—	—	—	—	—	287
151	18-	—	—	—	—	0126	0413	0699	0986	1272	1558	287
152	18-	1844	2129	2415	27	2985	327	3555	3839	4123	4407	285
153	18-	4691	4975	5259	5542	5825	6108	6391	6674	6956	7239	283
154	18-	7521	7803	8084	8366	8647	8928	9209	949	9771	—	281
154	*19-*	—	—	—	—	—	—	—	—	—	0051	281
No.		*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*D*

No.		0	1	2	3	4	5	6	7	8	9	D.
155	19-	0332	0612	0892	1171	1451	173	201	2289	2567	2846	279
156	19-	3125	3403	3681	3959	4237	4514	4792	5069	5346	5623	278
157	19-	59	6176	6453	6729	7005	7281	7556	7832	8107	8382	276
158	19-	8657	8932	9206	9481	9755	—	—	—	—	—	275
158	20-	—	—	—	—	—	0029	0303	0577	085	1124	274
159	20-	1397	167	1943	2216	2488	2761	3033	3305	3577	3848	272
160	20-	412	4391	4663	4934	5204	5475	5746	6016	6286	6556	271
161	20-	6826	7096	7365	7634	7904	8173	8441	871	8979	9247	269
162	20-	9515	9783	—	—	—	—	—	—	—	—	268
162	21-	—	—	0051	0319	0586	0853	1121	1388	1654	1921	267
163	21-	2188	2454	272	2986	3252	3518	3783	4049	4314	4579	266
164	21-	4844	5109	5373	5638	5902	6166	643	6694	6957	7221	264
165	21-	7484	7747	801	8273	8536	8798	906	9323	9585	9846	262
166	22-	0108	037	0631	0892	1153	1414	1675	1936	2196	2456	261
167	22-	2716	2976	3236	3496	3755	4015	4274	4533	4792	5051	259
168	22-	5309	5568	5826	6084	6342	66	6858	7115	7372	763	258
169	22-	7887	8144	84	8657	8913	917	9426	9682	9938	—	257
169	23-	—	—	—	—	—	—	—	—	—	0193	256
170	23-	0449	0704	096	1215	147	1724	1979	2234	2488	2742	255
171	23-	2996	325	3504	3757	4011	4264	4517	477	5023	5276	253
172	23-	5528	5781	6033	6285	6537	6789	7041	7292	7544	7795	252
173	23-	8046	8297	8548	8799	9049	9299	955	98	—	—	251
173	24-	—	—	—	—	—	—	—	—	005	03	250
174	24-	0549	0799	1048	1297	1546	1795	2044	2293	2541	279	249
175	24-	3038	3286	3534	3782	403	4277	4525	4772	5019	5266	248
176	24-	5513	5759	6006	6252	6499	6745	6991	7237	7482	7728	246
177	24-	7973	8219	8464	8709	8954	9198	9443	9687	9932	—	246
177	25-	—	—	—	—	—	—	—	—	—	0176	245
178	25-	042	0664	0908	1151	1395	1638	1881	2125	2368	261	243
179	25-	2853	3096	3338	358	3822	4064	4306	4548	479	5031	242
180	25-	5273	5514	5755	5996	6237	6477	6718	6958	7198	7439	241
181	25-	7679	7918	8158	8398	8637	8877	9116	9355	9594	9833	239
182	26-	0071	031	0548	0787	1025	1263	1501	1739	1976	2214	238
183	26-	2451	2688	2925	3162	3399	3636	3873	4109	4346	4582	237
184	26-	4818	5054	529	5525	5761	5996	6232	6467	6702	6937	235
185	26-	7172	7406	7641	7875	811	8344	8578	8812	9046	9279	234
186	26-	9513	9746	998	—	—	—	—	—	—	—	234
186	27-	—	—	—	0213	0446	0679	0912	1144	1377	1609	233
187	27-	1842	2074	2306	2538	277	3001	3233	3464	3696	3927	232
188	27-	4158	4389	462	485	5081	5311	5542	5772	6002	6232	230
189	27-	6462	6692	6921	7151	738	7609	7838	8067	8296	8525	229
190	27-	8754	8982	9211	9439	9667	9895	—	—	—	—	228
190	28-	—	—	—	—	—	—	0123	0351	0578	0806	228
191	28-	1033	1261	1488	1715	1942	2169	2396	2622	2849	3075	227
192	28-	3301	3527	3753	3979	4205	4431	4656	4882	5107	5332	226
193	28-	5557	5782	6007	6232	6456	6681	6905	713	7354	7578	225
194	28-	7802	8026	8249	8473	8696	892	9143	9366	9589	9812	223
195	29-	0035	0257	048	0702	0925	1147	1369	1591	1813	2034	222
196	29-	2256	2478	2699	292	3141	3363	3584	3804	4025	4246	221
197	29-	4466	4687	4907	5127	5347	5567	5787	6007	6226	6446	220
198	29-	6665	6884	7104	7323	7542	7761	7979	8198	8416	8635	219
199	29-	8853	9071	9289	9507	9725	9943	—	—	—	—	218
199	30-	—	—	—	—	—	—	0161	0378	0595	0813	218
No.		0	1	2	3	4	5	6	7	8	9	D.

No.		0	1	2	3	4	5	6	7	8	9	D'
200	30-	103	1247	1464	1681	1898	2114	2331	2547	2764	298	217
201	30-	3196	3412	3628	3844	4059	4275	4491	4706	4921	5136	216
202	30-	5351	5566	5781	5996	6211	6425	6639	6854	7068	7282	215
203	30-	7496	771	7924	8137	8351	8564	8778	8991	9204	9417	213
204	30-	963	9843	—	—	—	—	—	—	—	—	213
204	31-	—	—	0056	0268	0481	0693	0906	1118	133	1542	212
205	31-	1754	1966	2177	2389	26	2812	3023	3234	3445	3656	211
206	31-	3867	4078	4289	4499	471	492	513	534	5551	576	210
207	31-	597	618	639	6599	6809	7018	7227	7436	7646	7854	209
208	31-	8063	8272	8481	8689	8898	9106	9314	9522	973	9938	208
209	32-	0146	0354	0562	0769	0977	1184	1391	1598	1805	2012	207
210	32-	2219	2426	2633	2839	3046	3252	3458	3665	3871	4077	206
211	32-	4282	4488	4694	4899	5105	531	5516	5721	5926	6131	205
212	32-	6336	6541	6745	695	7155	7359	7563	7767	7972	8176	204
213	32-	838	8583	8787	8991	9194	9398	9601	9805	—	—	204
213	33-	—	—	—	—	—	—	—	—	0008	0211	203
214	33-	0414	0617	0819	1022	1225	1427	163	1832	2034	2236	202
215	33-	2438	264	2842	3044	3246	3447	3649	385	4051	4253	202
216	33-	4454	4655	4856	5057	5257	5458	5658	5859	6059	626	201
217	33-	646	666	686	706	726	7459	7659	7858	8058	8257	200
218	33-	8456	8656	8855	9054	9253	9451	965	9849	—	—	200
218	34-	—	—	—	—	—	—	—	—	0047	0246	199
219	34-	0444	0642	0841	1039	1237	1435	1632	183	2028	2225	198
220	34-	2423	262	2817	3014	3212	3409	3606	3802	3999	4196	197
221	34-	4392	4589	4785	4981	5178	5374	557	5766	5962	6157	196
222	34-	6353	6549	6744	6939	7135	733	7525	772	7915	811	195
223	34-	8305	85	8694	[illegible]	9083	9278	9472	9666	986	—	194
223	35-	—	—	—	—	—	—	—	—	—	0054	194
224	35-	0248	0442	0636	0829	1023	1216	141	1603	1796	1989	193
225	35-	2183	2375	2568	2761	2954	3147	3339	3532	3724	3916	193
226	35-	4108	4301	4493	4685	4876	5068	526	5452	5643	5834	192
227	35-	6026	6217	6408	6599	679	6981	7172	7363	7554	7744	191
228	35-	7935	8125	8316	8506	8696	8886	9076	9266	9456	9646	190
229	35-	9835	—	—	—	—	—	—	—	—	—	189
229	36-	—	0025	0215	0404	0593	0783	0972	1161	135	1539	189
230	36-	1728	1917	2105	2294	2482	2671	2859	3048	3236	3424	188
231	36-	3612	38	3988	4176	4363	4551	4739	4926	5113	5301	188
232	36-	5488	5675	5862	6049	6236	6423	661	6796	6983	7169	187
233	36-	7356	7542	7729	7915	8101	8287	8473	8659	8845	903	186
234	36-	9216	9401	9587	9772	9958	—	—	—	—	—	186
235	37-	—	—	—	—	—	0143	0328	0513	0698	0883	185
235	37-	1068	1253	1437	1622	1806	1991	2175	236	2544	2728	184
236	37-	2912	3096	328	3464	3647	3831	4015	4198	4382	4565	184
237	37-	4748	4932	5115	5298	5481	5664	5846	6029	6212	6394	183
238	37-	6577	6759	6942	7124	7306	7488	767	7852	8034	8216	182
239	37-	8398	858	8761	8943	9124	9306	9487	9668	9849	—	182
239	38-	—	—	—	—	—	—	—	—	—	003	181
240	38-	0211	0392	0573	0754	0934	1115	1296	1476	1656	1837	181
241	38-	2017	2197	2377	2557	2737	2917	3097	3277	3456	3636	180
242	38-	3815	3995	4174	4353	4533	4712	4891	507	5249	5428	179
243	38-	5606	5785	5964	6142	6321	6499	6677	6856	7034	7212	178
244	38-	739	7568	7746	7923	8101	8279	8456	8634	8811	8989	178
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No.		0	1	2	3	4	5	6	7	8	9	D.
245	38-	9166	9343	952	9698	9875	—	—	—	—	—	177
245	39-	—	—	—	—	—	0051	0228	0405	0582	0759	177
246	39-	0935	1112	1288	1464	1641	1817	1993	2169	2345	2521	176
247	39-	2697	2873	3048	3224	34	3575	3751	3926	4101	4277	176
248	39-	4452	4627	4802	4977	5152	5326	5501	5676	585	6025	175
249	39-	6199	6374	6548	6722	6896	7071	7245	7419	7592	7766	174
250	39-	794	8114	8287	8461	8634	8808	8981	9154	9328	9501	173
251	39-	9674	9847	—	—	—	—	—	—	—	—	173
251	40-	—	—	002	0192	0365	0538	0711	0883	1056	1228	173
252	40-	1401	1573	1745	1917	2089	2261	2433	2605	2777	2949	172
253	40-	3121	3292	3464	3635	3807	3978	4149	432	4492	4663	171
254	40-	4834	5005	5176	5346	5517	5688	5858	6029	6199	637	171
255	40-	654	671	6881	7051	7221	7391	7561	7731	7901	807	170
256	40-	824	841	8579	8749	8918	9087	9257	9426	9595	9764	169
257	40-	9933	—	—	—	—	—	—	—	—	—	169
257	41-	—	0102	0271	044	0609	0777	0946	1114	1283	1451	169
258	41-	162	1788	1956	2124	2293	2461	2629	2796	2964	3132	168
259	41-	33	3467	3635	3803	397	4137	4305	4472	4639	4806	167
260	41-	4973	514	5307	5474	5641	5808	5974	6141	6308	6474	167
261	41-	6641	6807	6973	7139	7306	7472	7638	7804	797	8135	166
262	41-	8301	8467	8633	8798	8964	9129	9295	946	9625	9791	165
263	41-	9956	—	—	—	—	—	—	—	—	—	165
263	42-	—	0121	0286	0451	0616	0781	0945	111	1275	1439	165
264	42-	1604	1768	1933	2097	2261	2426	259	2754	2918	3082	164
265	42-	3246	341	3574	3737	3901	4065	4228	4392	4555	4718	164
266	42-	4882	5045	5208	5371	5534	5697	586	6023	6186	6349	163
267	42-	6511	6674	6836	6999	7161	7324	7486	7648	7811	7973	162
268	42-	8135	8297	8459	8621	8783	8944	9106	9268	9429	9591	162
269	42-	9752	9914	—	—	—	—	—	—	—	—	162
269	43-	—	—	0075	0236	0398	0559	072	0881	1042	1203	161
270	43-	1364	1525	1685	1846	2007	2167	2328	2488	2649	2809	161
271	43-	2969	313	329	345	361	377	393	409	4249	4409	160
272	43-	4569	4729	4888	5048	5207	5367	5526	5685	5844	6004	159
273	43-	6163	6322	6481	664	6799	6957	7116	7275	7433	7592	159
274	43-	7751	7909	8067	8226	8384	8542	8701	8859	9017	9175	158
275	43-	9333	9491	9648	9806	9964	—	—	—	—	—	158
275	44-	—	—	—	—	—	0122	0279	0437	0594	0752	158
276	44-	0909	1066	1224	1381	1538	1695	1852	2009	2166	2323	157
277	44-	248	2637	2793	295	3106	3263	3419	3576	3732	3889	157
278	44-	4045	4201	4357	4513	4669	4825	4981	5137	5293	5449	156
279	44-	5604	576	5915	6071	6226	6382	6537	6692	6848	7003	155
280	44-	7158	7313	7468	7623	7778	7933	8088	8242	8397	8552	155
281	44-	8706	8861	9015	917	9324	9478	9633	9787	9941	—	154
281	45-	—	—	—	—	—	—	—	—	—	0095	154
282	45-	0249	0403	0557	0711	0865	1018	1172	1326	1479	1633	154
283	45-	1786	194	2093	2247	24	2553	2706	2859	3012	3165	153
284	45-	3318	3471	3624	3777	393	4082	4235	4387	454	4692	153
285	45-	4845	4997	515	5302	5454	5606	5758	591	6062	6214	152
286	45-	6366	6518	667	6821	6973	7125	7276	7428	7579	7731	152
287	45-	7882	8033	8184	8336	8487	8638	8789	894	9091	9242	151
288	45-	9392	9543	9694	9845	9995	—	—	—	—	—	151
288	46-	—	—	—	—	—	0146	0296	0447	0597	0748	151
289	46-	0898	1048	1198	1348	1499	1649	1799	1948	2098	2248	150
No.		0	1	2	3	4	5	6	7	8	9	D.

No.	0	1	2	3	4	5	6	7	8	9	D
290	46- 2398	2548	2697	2847	2997	3146	3296	3445	3594	3744	150
291	46- 3893	4042	4191	434	449	4639	4788	4936	5085	5234	149
292	46- 5383	5532	568	5829	5977	6126	6274	6423	6571	6719	149
293	46- 6868	7016	7164	7312	746	7608	7756	7904	8052	82	148
294	46- 8347	8495	8643	879	8938	9085	9233	938	9527	9675	148
295	46- 9822	9969	—	—	—	—	—	—	—	—	147
295	47- —	—	0116	0263	041	0557	0704	0851	0998	1145	147
296	47- 1292	1438	1585	1732	1878	2025	2171	2318	2464	261	146
297	47- 2756	2903	3049	3195	3341	3487	3633	3779	3925	4071	146
298	47- 4216	4362	4508	4653	4799	4944	509	5235	5381	5526	146
299	47- 5671	5816	5962	6107	6252	6397	6542	6687	6832	6976	145
300	47- 7121	7266	7411	7555	77	7844	7989	8133	8278	8422	145
301	47- 8566	8711	8855	8999	9143	9287	9431	9575	9719	9863	144
302	48- 0007	0151	0294	0438	0582	0725	0869	1012	1156	1299	144
303	48- 1443	1586	1729	1872	2016	2159	2302	2445	2588	2731	143
304	48- 2874	3016	3159	3302	3445	3587	373	3872	4015	4157	143
305	48- 43	4442	4585	4727	4869	5011	5153	5295	5437	5579	142
306	48- 5721	5863	6005	6147	6289	643	6572	6714	6855	6997	142
307	48- 7138	728	7421	7563	7704	7845	7986	8127	8269	841	141
308	48- 8551	8692	8833	8974	9114	9255	9396	9537	9677	9818	141
309	48- 9958	—	—	—	—	—	—	—	—	—	140
309	49- —	0099	0239	038	052	0661	0801	0941	1081	1222	140
310	49- 1362	1502	1642	1782	1922	2062	2201	2341	2481	2621	140
311	49- 276	29	304	3179	3319	3458	3597	3737	3876	4015	139
312	49- 4155	4294	4433	4572	4711	485	4989	5128	5267	5406	139
313	49- 5544	5683	5822	596	6099	6238	6376	6515	6653	6791	139
314	49- 693	7068	7206	7344	7483	7621	7759	7897	8035	8173	138
315	49- 8311	8448	8586	8724	8862	8999	9137	9275	9412	955	138
316	49- 9687	9824	9962	—	—	—	—	—	—	—	137
316	50- —	—	—	0099	0236	0374	0511	0648	0785	0922	137
317	50- 1059	1196	1333	147	1607	1744	188	2017	2154	2291	137
318	50- 2427	2564	27	2837	2973	3109	3246	3382	3518	3655	136
319	50- 3791	3927	4063	4199	4335	4471	4607	4743	4878	5014	136
320	50- 515	5286	5421	5557	5693	5828	5964	6099	6234	637	136
321	50- 6505	664	6776	6911	7046	7181	7316	7451	7586	7721	135
322	50- 7856	7991	8126	826	8395	853	8664	8799	8934	9068	135
323	50- 9203	9337	9471	9606	974	9874	—	—	—	—	134
323	51- —	—	—	—	—	—	0009	0143	0277	0411	134
324	51- 0545	0679	0813	0947	1081	1215	1349	1482	1616	175	134
325	51- 1883	2017	2151	2284	2418	2551	2684	2818	2951	3084	133
326	51- 3218	3351	3484	3617	375	3883	4016	4149	4282	4415	133
327	51- 4548	4681	4813	4946	5079	5211	5344	5476	5609	5741	133
328	51- 5874	6006	6139	6271	6403	6535	6668	68	6932	7064	132
329	51- 7196	7328	746	7592	7724	7855	7987	8119	8251	8382	132
330	51- 8514	8646	8777	8909	904	9171	9303	9434	9566	9697	131
331	51- 9828	9959	—	—	—	—	—	—	—	—	131
331	52- —	—	009	0221	0353	0484	0615	0745	0876	1007	131
332	52- 1138	1269	14	153	1661	1792	1922	2053	2183	2314	131
333	52- 2444	2575	2705	2835	2966	3096	3226	3356	3486	3616	130
334	52- 3746	3876	4006	4136	4266	4396	4526	4656	4785	4915	130
No.	0	1	2	3	4	5	6	7	8	9	D

No.		0	1	2	3	4	5	6	7	8	9	D
335	52-	5045	5174	5304	5434	5563	5693	5822	5951	6081	621	129
336	52-	6339	6469	6598	6727	6856	6985	7114	7243	7372	7501	129
337	52-	763	7759	7888	8016	8145	8274	8402	8531	866	8788	129
338	52-	8917	9045	9174	9302	943	9559	9687	9815	9943	—	128
338	53-	—	—	—	—	—	—	—	—	—	0072	128
339	53-	02	0328	0456	0584	0712	084	0968	1096	1223	1351	128
340	53-	1479	1607	1734	1862	199	2117	2245	2372	25	2627	128
341	53-	2754	2882	3009	3136	3264	3391	3518	3645	3772	3899	127
342	53-	4026	4153	428	4407	4534	4661	4787	4914	5041	5167	127
343	53-	5294	5421	5547	5674	58	5927	6053	618	6306	6432	126
344	53-	6558	6685	6811	6937	7063	7189	7315	7441	7567	7693	126
345	53-	7819	7945	8071	8197	8322	8448	8574	8699	8825	8951	126
346	53-	9076	9202	9327	9452	9578	9703	9829	9954	—	—	126
346	54-	—	—	—	—	—	—	—	—	0079	0204	125
347	54-	0329	0455	058	0705	083	0955	108	1205	133	1454	125
348	54-	1579	1704	1829	1953	2078	2203	2327	2452	2576	2701	125
349	54-	2825	295	3074	3199	3323	3447	3571	3696	382	3944	124
350	54-	4068	4192	4316	444	4564	4688	4812	4936	506	5183	124
351	54-	5307	5431	5555	5678	5802	5925	6049	6172	6296	6419	124
352	54-	6543	6666	6789	6913	7036	7159	7282	7405	7529	7652	123
353	54-	7775	7898	8021	8144	8267	8389	8512	8635	8758	8881	123
354	54-	9003	9126	9249	9371	9494	9616	9739	9861	9984	—	123
354	55-	—	—	—	—	—	—	—	—	—	0106	123
355	55-	0228	0351	0473	0595	0717	084	0962	1084	1206	1328	122
356	55-	145	1572	1694	1816	1938	206	2181	2303	2425	2547	122
357	55-	2668	279	2911	3033	3155	3276	3398	3519	364	3762	121
358	55-	3883	4004	4126	4247	4368	4489	461	4731	4852	4973	121
359	55-	5094	5215	5336	5457	5578	5699	582	594	6061	6182	121
360	55-	6303	6423	6544	6664	6785	6905	7026	7146	7267	7387	120
361	55-	7507	7627	7748	7868	7988	8108	8228	8349	8469	8589	120
362	55-	8709	8829	8948	9068	9188	9308	9428	9548	9667	9787	120
363	55-	9907	—	—	—	—	—	—	—	—	—	120
363	56-	—	0026	0146	0265	0385	0504	0624	0743	0863	0982	119
364	56-	1101	1221	134	1459	1578	1698	1817	1936	2055	2174	119
365	56-	2293	2412	2531	265	2769	2887	3006	3125	3244	3362	119
366	56-	3481	36	3718	3837	3955	4074	4192	4311	4429	4548	119
367	56-	4666	4784	4903	5021	5139	5257	5376	5494	5612	573	118
368	56-	5848	5966	6084	6202	632	6437	6555	6673	6791	6909	118
369	56-	7026	7144	7262	7379	7497	7614	7732	7849	7967	8084	118
370	56-	8202	8319	8436	8554	8671	8788	8905	9023	914	9257	117
371	56-	9374	9491	9608	9725	9842	9959	—	—	—	—	117
371	57-	—	—	—	—	—	—	0076	0193	0309	0426	117
372	57-	0543	066	0776	0893	101	1126	1243	1359	1476	1592	117
373	57-	1709	1825	1942	2058	2174	2291	2407	2523	2639	2755	116
374	57-	2872	2988	3104	322	3336	3452	3568	3684	38	3915	116
375	57-	4031	4147	4263	4379	4494	461	4726	4841	4957	5072	116
376	57-	5188	5303	5419	5534	565	5765	588	5996	6111	6226	115
377	57-	6341	6457	6572	6687	6802	6917	7032	7147	7262	7377	115
378	57-	7492	7607	7722	7836	7951	8066	8181	8295	841	8525	115
379	57-	8639	8754	8868	8983	9097	9212	9326	9441	9555	9669	114
No.		0	1	2	3	4	5	6	7	8	9	D

No.	0	1	2	3	4	5	6	7	8
[illegible]	46 1368	1518	1667	1847	1997	3146	3296	3445	[illegible]
[illegible]	46 3693	4042	4191	432	4481	1639	4788	4936	[illegible]
[illegible]	46 5383	5532	568	5829	5977	6126	6274	6423	[illegible]
[illegible]	46 6868	7016	7164	7312	746	7608	7756	7904	[illegible]
[illegible]	46 8347	8495	8643	879	8938	9085	9233	938	[illegible]
[illegible]	46 9822	9969	—	—	—	—	—	—	—
[illegible]	47 —	—	0116	0263	041	0557	0704	0851	[illegible]
[illegible]	47 1292	1438	1585	1732	1878	2025	2171	2318	[illegible]
[illegible]	47 2756	2903	3049	3195	3341	3487	3633	3779	[illegible]
[illegible]	47 4216	4362	4508	4653	4799	4944	509	5235	[illegible]
[illegible]	47 5671	5816	5962	6107	6252	6397	6542	6687	[illegible]
[illegible]	47 7121	7266	7411	7555	77	7844	7989	8133	[illegible]
[illegible]	47 8566	8711	8855	8999	9143	9287	9431	9575	[illegible]
[illegible]	48 0007	0151	0294	0438	0582	0725	0869	1012	[illegible]
[illegible]	48 1443	1586	1729	1872	2016	2159	2302	2445	[illegible]
[illegible]	48 2874	3016	3159	3302	3445	3587	373	3872	[illegible]
[illegible]	48 [illegible]	4442	4585	4727	4869	5011	5153	5295	[illegible]
[illegible]	48 5721	5863	6005	6147	6289	643	6572	6714	[illegible]
[illegible]	48 7138	728	7421	7563	7704	7845	7986	8127	[illegible]
[illegible]	48 8551	8692	8833	8974	9114	9255	9396	9537	[illegible]
[illegible]	48 9958	—	—	—	—	—	—	—	[illegible]
[illegible]	49 —	0099	0239	038	052	0661	0801	0941	[illegible]
[illegible]	[illegible]	[illegible]	1642	1782	1922	2062	2201	2341	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	3179	3319	3458	3597	3737	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	4572	4711	485	4989	5128	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6236	6376	6515	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	7344	7483	7621	7759	7897	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9137	9275	[illegible]

No.	0	1	2	3	4	5	6	7	8	9	D
:85	52- 5945	5174	5304	5434	5563	5693	5822	5951	6081	621	129
336	52- 6339	6469	6598	6727	6856	6985	7114	7243	7372	7501	129
337	52- 763	7759	7888	8016	8145	8274	8403	8531	806	8788	129
338	52- 8917	9045	9174	9302	943	9559	9687	9815	9943	—	128
338	53- —	—	—	—	—	—	—	—	—	0072	128
339	53- 02	0328	0456	0584	0712	084	0968	1096	1223	1351	128
340	53- 1479	1607	1734	1862	199	2117	2245	2372	25	2627	128
341	53- 2754	2882	3009	3136	3264	3391	3518	3645	3772	3899	127
342	53- 4026	4153	428	4407	4534	4661	4787	4914	5041	5167	127
343	53- 5294	5421	5547	5674	58	5927	6053	618	6306	6432	126
344	53- 6558	6685	6811	6937	7063	7189	7315	7441	7567	7693	126
345	53- 7819	7945	8071	8197	8322	8448	8574	8699	8825	8951	126
346	53- 9076	9202	9327	9452	9578	9703	9829	9954	—	—	126
346	54- —	—	—	—	—	—	—	—	0079	0204	125
347	54- 0329	0455	058	0705	083	0955	108	1205	133	1454	125
348	54- 1579	1704	1829	1953	2078	2203	2327	2452	2576	2701	125
349	54- 2825	295	3074	3199	3323	3447	3571	3696	382	3944	124
350	54- 4068	4192	4316	444	4564	4688	4812	4936	506	5183	124
351	54- 5307	5431	5555	5678	5802	5925	6049	6172	6296	6419	124
352	54- 6543	6666	6789	6913	7036	7159	7282	7405	7529	7652	123
353	54- 7775	7898	8021	8144	8267	8389	8512	8635	8758	8881	123
354	54- 9003	9126	9249	9371	9494	9616	9739	9861	9984	—	123
354	55- —	—	—	—	—	—	—	—	—	0106	123
355	55- 0228	0351	0473	0595	0717	084	0962	1084	1206	1328	122
356	55- 145	1572	1694	1816	1938	206	2181	2303	2425	2547	122
357	55- 2668	279	2911	3033	3155	3276	3398	3519	364	3762	121
358	55- 3883	4004	4126	4247	4368	4489	461	4731	4852	4973	121
359	55- 5094	5215	5336	5457	5578	5699	582	594	6061	6182	121
360	55- 6303	6423	6544	6664	6785	6905	7026	7146	7267	7387	120
361	55- 7507	7627	7748	7868	7988	8108	8228	8349	8469	8589	120
362	55- 8709	8829	8948	9068	9188	9308	9428	9548	9667	9787	120
363	55- 9907	—	—	—	—	—	—	—	—	—	120
363	56- —	0026	0146	0265	0385	0504	0624	0743	0863	0982	119
364	56- 1101	1221	134	1459	1578	1698	1817	1936	2055	2174	119
365	56- 2293	2412	2531	265	2769	2887	3006	3125	3244	3362	119
366	56- 3481	36	3718	3837	3955	4074	4192	4311	4429	4548	119
[illegible]	56- 4666	4784	4903	5021	5139	5257	5376	5494	5612	573	118
[illegible]	5848	5966	6084	6202	632	6437	6555	6673	6791	6909	118
[illegible]	[illegible]	7144	7262	7379	7497	7614	7732	7849	7967	8084	118
[illegible]	[illegible]	8319	8436	8554	8671	8788	8905	9023	914	9257	117
[illegible]	[illegible]	[illegible]	9608	9725	9842	9959	—	—	—	—	117
[illegible]	[illegible]	[illegible]	—	—	—	—	0076	0193	0309	0426	117
[illegible]	[illegible]	[illegible]	0776	0893	101	1126	1243	1359	1476	1592	117
[illegible]	[illegible]	[illegible]	1942	2058	2174	2291	2407	2523	2639	2755	116
[illegible]	[illegible]	[illegible]	[illegible]	322	3336	3452	3568	3684	38	3915	116
[illegible]	[illegible]	[illegible]	[illegible]	4379	4494	461	4726	4841	4957	5072	116
[illegible]	[illegible]	[illegible]	[illegible]	5534	565	5765	588	5996	6111	6226	115
[illegible]	[illegible]	[illegible]	[illegible]	6687	6802	6917	7032	7147	7262	7377	115
[illegible]	[illegible]	[illegible]	[illegible]	7836	7951	8066	8181	8295	841	8525	115
[illegible]	[illegible]	[illegible]	[illegible]	8983	9097	9212	9326	9441	9555	9669	114
				3	4	5	6	7	8	9	D

No.		0	1	2	3	4	5	6	7	8	9	D
380	57-	9784	9898	—	—	—	—	—	—	—	—	114
380	58-	—	—	0012	0126	0241	0355	0469	0583	0697	0811	114
381	58-	0925	1039	1153	1267	1381	1495	1608	1722	1836	195	114
382	58-	2063	2177	2291	2404	2518	2631	2745	2858	2972	3085	114
383	58-	3199	3312	3426	3539	3652	3765	3879	3992	4105	4218	113
384	58-	4331	4444	4557	467	4783	4896	5009	5122	5235	5348	113
385	58-	5461	5574	5686	5799	5912	6024	6137	625	6362	6475	113
386	58-	6587	67	6812	6925	7037	7149	7262	7374	7486	7599	112
387	58-	7711	7823	7935	8047	816	8272	8384	8496	8608	872	112
388	58-	8832	8944	9056	9167	9279	9391	9503	9615	9726	9838	112
389	58-	995	—	—	—	—	—	—	—	—	—	112
389	59-	—	0061	0173	0284	0396	0507	0619	073	0842	0953	112
390	59-	1065	1176	1287	1399	151	1621	1732	1843	1955	2066	111
391	59-	2177	2288	2399	251	2621	2732	2843	2954	3064	3175	111
392	59-	3286	3397	3508	3618	3729	384	395	4061	4171	4282	111
393	59-	4393	4503	4614	4724	4834	4945	5055	5165	5276	5386	110
394	59-	5496	5606	5717	5827	5937	6047	6157	6267	6377	6487	110
395	59-	6597	6707	6817	6927	7037	7146	7256	7366	7476	7586	110
396	59-	7695	7805	7914	8024	8134	8243	8353	8462	8572	8681	110
397	59-	8791	89	9009	9119	9228	9337	9446	9556	9665	9774	109
398	59-	9883	9992	—	—	—	—	—	—	—	—	109
398	60-	—	—	0101	021	0319	0428	0537	0646	0755	0864	109
399	60-	0973	1082	1191	1299	1408	1517	1625	1734	1843	1951	109
400	60-	206	2169	2277	2386	2494	2603	2711	2819	2928	3036	108
401	60-	3144	3253	3361	3469	3577	3686	3794	3902	401	4118	108
402	60-	4226	4334	4442	455	4658	4766	4874	4982	5089	5197	108
403	60-	5305	5413	5521	5628	5736	5844	5951	6059	6166	6274	108
404	60-	6381	6489	6596	6704	6811	6919	7026	7133	7241	7348	107
405	60-	7455	7562	7669	7777	7884	7991	8098	8205	8312	8419	107
406	60-	8526	8633	874	8847	8954	9061	9167	9274	9381	9488	107
407	60-	9594	9701	9808	9914	—	—	—	—	—	—	107
407	61-	—	—	—	—	0021	0128	0234	0341	0447	0554	107
408	61-	066	0767	0873	0979	1086	1192	1298	1405	1511	1617	106
409	61-	1723	1829	1936	2042	2148	2254	236	2466	2572	2678	106
410	61-	2784	289	2996	3102	3207	3313	3419	3525	363	3736	106
411	61-	3842	3947	4053	4159	4264	437	4475	4581	4686	4792	106
412	61-	4897	5003	5108	5213	5319	5424	5529	5634	574	5845	105
413	61-	595	6055	616	6265	637	6476	6581	6686	679	6895	105
414	61-	7	7105	721	7315	742	7525	7629	7734	7839	7943	105
415	61-	8048	8153	8257	8362	8466	8571	8676	878	8884	8989	105
416	61-	9093	9198	9302	9406	9511	9615	9719	9824	9928	—	105
416	62-	—	—	—	—	—	—	—	—	—	0032	104
417	62-	0136	024	0344	0448	0552	0656	076	0864	0968	1072	104
418	62-	1176	128	1384	1488	1592	1695	1799	1903	2007	211	104
419	62-	2214	2318	2421	2525	2628	2732	2835	2939	3042	3146	104
420	62-	3249	3353	3456	3559	3663	3766	3869	3973	4076	4179	103
421	62-	4282	4385	4488	4591	4695	4798	4901	5004	5107	521	103
422	62-	5312	5415	5518	5621	5724	5827	5929	6032	6135	6238	103
423	62-	634	6443	6546	6648	6751	6853	6956	7058	7161	7263	103
424	62-	7366	7468	7571	7673	7775	7878	798	8082	8185	8287	102
No.		0	1	2	3	4	5	6	7	8	9	D

No.		0	1	2	3	4	5	6	7	8	9	D
425	62-	8389	8491	8593	8695	8797	89	9002	9104	9206	9308	102
426	62-	941	9512	9613	9715	9817	9919	—	—	—	—	102
426	63-	—	—	—	—	—	—	0021	0123	0224	0326	102
427	63-	0428	053	0631	0733	0835	0936	1038	1139	1241	1342	102
428	63-	1444	1545	1647	1748	1849	1951	2052	2153	2255	2356	101
429	63-	2457	2559	266	2761	2862	2963	3064	3165	3266	3367	101
430	63-	3468	3569	367	3771	3872	3973	4074	4175	4276	4376	101
431	63-	4477	4578	4679	4779	488	4981	5081	5182	5283	5383	101
432	63-	5484	5584	5685	5785	5886	5986	6087	6187	6287	6388	100
433	63-	6488	6588	6688	6789	6889	6989	7089	7189	729	739	100
434	63-	749	759	769	779	789	799	809	819	829	8389	100
435	63-	8489	8589	8689	8789	8888	8988	9088	9188	9287	9387	100
436	63-	9486	9586	9686	9785	9885	9984	—	—	—	—	100
436	64-	—	—	—	—	—	—	0084	0183	0283	0382	99
437	64-	0481	0581	068	0779	0879	0978	1077	1177	1276	1375	99
438	64-	1474	1573	1672	1771	1871	197	2069	2168	2267	2366	99
439	64-	2465	2563	2662	2761	286	2959	3058	3156	3255	3354	99
440	64-	3453	3551	365	3749	3847	3946	4044	4143	4242	434	99
441	64-	4439	4537	4636	4734	4832	4931	5029	5127	5226	5324	98
442	64-	5422	5521	5619	5717	5815	5913	6011	611	6208	6306	98
443	64-	6404	6502	66	6698	6796	6894	6992	7089	7187	7285	98
444	64-	7383	7481	7579	7676	7774	7872	7969	8067	8165	8262	98
445	64-	836	8458	8555	8653	875	8848	8945	9043	914	9237	97
446	64-	9335	9432	953	9627	9724	9821	9919	—	—	—	97
446	65-	—	—	—	—	—	—	—	0016	0113	021	97
447	65-	0308	0405	0502	0599	0696	0793	089	0987	1084	1181	97
448	65-	1278	1375	1472	1569	1666	1762	1859	1956	2053	215	97
449	65-	2246	2343	244	2536	2633	273	2826	2923	3019	3116	97
450	65-	3213	3309	3405	3502	3598	3695	3791	3888	3984	408	96
451	65-	4177	4273	4369	4465	4562	4658	4754	485	4946	5042	96
452	65-	5138	5235	5331	5427	5523	5619	5715	581	5906	6002	96
453	65-	6098	6194	629	6386	6482	6577	6673	6769	6864	696	96
454	65-	7056	7152	7247	7343	7438	7534	7629	7725	782	7916	96
455	65-	8011	8107	8202	8298	8393	8488	8584	8679	8774	887	95
456	65-	8965	906	9155	925	9346	9441	9536	9631	9726	9821	95
457	65-	9916	—	—	—	—	—	—	—	—	—	95
457	66-	—	0011	0106	0201	0296	0391	0486	0581	0676	0771	95
458	66-	0865	096	1055	115	1245	1339	1434	1529	1623	1718	95
459	66-	1813	1907	2002	2096	2191	2286	238	2475	2569	2663	95
460	66-	2758	2852	2947	3041	3135	323	3324	3418	3512	3607	94
461	66-	3701	3795	3889	3983	4078	4172	4266	436	4454	4548	94
462	66-	4642	4736	483	4924	5018	5112	5206	5299	5393	5487	94
463	66-	5581	5675	5769	5862	5956	605	6143	6237	6331	6424	94
464	66-	6518	6612	6705	6799	6892	6986	7079	7173	7266	736	94
465	66-	7453	7546	764	7733	7826	792	8013	8106	8199	8293	93
466	66-	8386	8479	8572	8665	8759	8852	8945	9038	9131	9224	93
467	66-	9317	941	9503	9596	9689	9782	9875	9967	—	—	93
467	67-	—	—	—	—	—	—	—	—	006	0153	93
468	67-	0246	0339	0431	0524	0617	071	0802	0895	0988	108	93
469	67-	1173	1265	1358	1451	1543	1636	1728	1821	1913	2005	93
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470	67-	2098	219	2283	2375	2467	256	2652	2744	2836	2929	92
471	67-	3021	3113	3205	3297	339	3482	3574	3666	3758	385	92
472	67-	3942	4034	4126	4218	431	4402	4494	4586	4677	4769	92
473	67-	4861	4953	5045	5137	5228	532	5412	5503	5595	5687	92
474	67-	5778	587	5962	6053	6145	6236	6328	6419	6511	6602	92
475	67-	6694	6785	6876	6968	7059	7151	7242	7333	7424	7516	91
476	67-	7607	7698	7789	7881	7972	8063	8154	8245	8336	8427	91
477	67-	8518	8609	87	8791	8882	8973	9064	9155	9246	9337	91
478	67-	9428	9519	961	97	9791	9882	9973	—	—	—	91
478	68-	—	—	—	—	—	—	—	0063	0154	0245	91
479	68-	0336	0426	0517	0607	0698	0789	0879	097	106	1151	91
480	68-	1241	1332	1422	1513	1603	1693	1784	1874	1964	2055	90
481	68-	2145	2235	2326	2416	2506	2596	2686	2777	2867	2957	90
482	68-	3047	3137	3227	3317	3407	3497	3587	3677	3767	3857	90
483	68-	3947	4037	4127	4217	4307	4396	4486	4576	4666	4756	90
484	68-	4845	4935	5025	5114	5204	5294	5383	5473	5563	5652	90
485	68-	5742	5831	5921	601	61	6189	6279	6368	6458	6547	89
486	68-	6636	6726	6815	6904	6994	7083	7172	7261	7351	744	89
487	68-	7529	7618	7707	7796	7886	7975	8064	8153	8242	8331	89
488	68-	842	8509	8598	8687	8776	8865	8953	9042	9131	922	89
489	68-	9309	9398	9486	9575	9664	9753	9841	993	—	—	89
489	69-	—	—	—	—	—	—	—	—	0019	0107	89
490	69-	0196	0285	0373	0462	055	0639	0728	0816	0905	0993	89
491	69-	1081	117	1258	1347	1435	1524	1612	17	1789	1877	88
492	69-	1965	2053	2142	223	2318	2406	2494	2583	2671	2759	88
493	69-	2847	2935	3023	3111	3199	3287	3375	3463	3551	3639	88
494	69-	3727	3815	3903	3991	4078	4166	4254	4342	443	4517	88
495	69-	4605	4693	4781	4868	4956	5044	5131	5219	5307	5394	88
496	69-	5482	5569	5657	5744	5832	5919	6007	6094	6182	6269	87
497	69-	6356	6444	6531	6618	6706	6793	688	6968	7055	7142	87
498	69-	7229	7317	7404	7491	7578	7665	7752	7839	7926	8014	87
499	69-	8101	8188	8275	8362	8449	8535	8622	8709	8796	8883	87
500	69-	897	9057	9144	9231	9317	9404	9491	9578	9664	9751	87
501	69-	9838	9924	—	—	—	—	—	—	—	—	87
501	70-	—	—	0011	0098	0184	0271	0358	0444	0531	0617	87
502	70-	0704	079	0877	0963	105	1136	1222	1309	1395	1482	86
503	70-	1568	1654	1741	1827	1913	1999	2086	2172	2258	2344	86
504	70-	2431	2517	2603	2689	2775	2861	2947	3033	3119	3205	86
505	70-	3291	3377	3463	3549	3635	3721	3807	3893	3979	4065	86
506	70-	4151	4236	4322	4408	4494	4579	4665	4751	4837	4922	86
507	70-	5008	5094	5179	5265	535	5436	5522	5607	5693	5778	86
508	70-	5864	5949	6035	612	6206	6291	6376	6462	6547	6632	85
509	70-	6718	6803	6888	6974	7059	7144	7229	7315	74	7485	85
510	70-	757	7655	774	7826	7911	7996	8081	8166	8251	8336	85
511	70-	8421	8506	8591	8676	8761	8846	8931	9015	91	9185	85
512	70-	927	9355	944	9524	9609	9694	9779	9863	9948	—	85
512	71-	—	—	—	—	—	—	—	—	—	0033	85
513	71-	0117	0202	0287	0371	0456	054	0625	071	0794	0879	85
514	71-	0963	1048	1132	1217	1301	1385	147	1554	1639	1723	84
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515	71-	1807	1892	1976	206	2144	2229	2313	2397	2481	2566	84
516	71-	265	2734	2818	2902	2986	307	3154	3238	3323	3407	84
517	71-	3491	3575	3659	3742	3826	391	3994	4078	4162	4246	84
518	71-	433	4414	4497	4581	4665	4749	4833	4916	5	5084	84
519	71-	5167	5251	5335	5418	5502	5586	5669	5753	5836	592	84
520	71-	6003	6087	617	6254	6337	6421	6504	6588	6671	6754	83
521	71-	6838	6921	7004	7088	7171	7254	7338	7421	7504	7587	83
522	71-	7671	7754	7837	792	8003	8086	8169	8253	8336	8419	83
523	71-	8502	8585	8668	8751	8834	8917	9	9083	9165	9248	83
524	71-	9331	9414	9497	958	9663	9745	9828	9911	9994	—	83
524	72-	—	—	—	—	—	—	—	—	—	0077	83
525	72-	0159	0242	0325	0407	049	0573	0655	0738	0821	0903	83
526	72-	0986	1068	1151	1233	1316	1398	1481	1563	1646	1728	82
527	72-	1811	1893	1975	2058	214	2222	2305	2387	2469	2552	82
528	72-	2634	2716	2798	2881	2963	3045	3127	3209	3291	3374	82
529	72-	3456	3538	362	3702	3784	3866	3948	403	4112	4194	82
530	72-	4276	4358	444	4522	4604	4685	4767	4849	4931	5013	82
531	72-	5095	5176	5258	534	5422	5503	5585	5667	5748	583	82
532	72-	5912	5993	6075	6156	6238	632	6401	6483	6564	6646	82
533	72-	6727	6809	689	6972	7053	7134	7216	7297	7379	746	81
534	72-	7541	7623	7704	7785	7866	7948	8029	811	8191	8273	81
535	72-	8354	8435	8516	8597	8678	8759	8841	8922	9003	9084	81
536	72-	9165	9246	9327	9408	9489	957	9651	9732	9813	9893	81
537	72-	9974	—	—	—	—	—	—	—	—	—	81
537	73-	—	0055	0136	0217	0298	0378	0459	054	0621	0702	81
538	73-	0782	0863	0944	1024	1105	1186	1266	1347	1428	1508	81
539	73-	1589	1669	175	183	1911	1991	2072	2152	2233	2313	81
540	73-	2394	2474	2555	2635	2715	2796	2876	2956	3037	3117	80
541	73-	3197	3278	3358	3438	3518	3598	3679	3759	3839	3919	80
542	73-	3999	4079	416	424	432	44	448	456	464	472	80
543	73-	48	488	496	504	512	52	5279	5359	5439	5519	80
544	73-	5599	5679	5759	5838	5918	5998	6078	6157	6237	6317	80
545	73-	6397	6476	6556	6635	6715	6795	6874	6954	7034	7113	80
546	73-	7193	7272	7352	7431	7511	759	767	7749	7829	7908	79
547	73-	7987	8067	8146	8225	8305	8384	8463	8543	8622	8701	79
548	73-	8781	886	8939	9018	9097	9177	9256	9335	9414	9493	79
549	73-	9572	9651	9731	981	9889	9968	—	—	—	—	79
549	74-	—	—	—	—	—	—	0047	0126	0205	0284	79
550	74-	0363	0442	0521	06	0678	0757	0836	0915	0994	1073	79
551	74-	1152	123	1309	1388	1467	1546	1624	1703	1782	186	79
552	74-	1939	2018	2096	2175	2254	2332	2411	2489	2568	2647	79
553	74-	2725	2804	2882	2961	3039	3118	3196	3275	3353	3431	78
554	74-	351	3588	3667	3745	3823	3902	398	4058	4136	4215	78
555	74-	4293	4371	4449	4528	4606	4684	4762	484	4919	4997	78
556	74-	5075	5153	5231	5309	5387	5465	5543	5621	5699	5777	78
557	74-	5855	5933	6011	6089	6167	6245	6323	6401	6479	6556	78
558	74-	6634	6712	679	6868	6945	7023	7101	7179	7256	7334	78
559	74-	7412	7489	7567	7645	7722	78	7878	7955	8033	811	78
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560	74-	8188	8266	8343	8421	8498	8576	8653	8731	8808	[illegible]	77
561	74-	8963	904	9118	9195	9272	935	9427	9504	9582	[illegible]	[illegible]
562	74-	9736	9814	9891	9968	—	—	—	—	—	—	77
562	75-	—	—	—	—	0045	0123	02	0277	0354	0431	77
563	75-	0508	0586	0663	074	0817	0894	0971	1048	1125	1202	77
564	75-	1279	1356	1433	151	1587	1664	1741	1818	1895	1972	77
565	75-	2048	2125	2202	2279	2356	2433	2509	2586	2663	274	77
566	75-	2816	2893	297	3047	3123	32	3277	3353	343	3506	77
567	75-	3583	366	3736	3813	3889	3966	4042	4119	4195	4272	77
568	75-	4348	4425	4501	4578	4654	473	4807	4883	496	5036	76
569	75-	5112	5189	5265	5341	5417	5494	557	5646	5722	5799	76
570	75-	5875	5951	6027	6103	618	6256	6332	6408	6484	656	76
571	75-	6636	6712	6788	6864	694	7016	7092	7168	7244	732	76
572	75-	7396	7472	7548	7624	77	7775	7851	7927	8003	8079	76
573	75-	8155	823	8306	8382	8458	8533	8609	8685	8761	8836	76
574	75-	8912	8988	9063	9139	9214	929	9366	9441	9517	9592	76
575	75-	9668	9743	9819	9894	997	—	—	—	—	—	76
575	76-	—	—	—	—	—	0045	0121	0196	0272	0347	75
576	76-	0422	0498	0573	0649	0724	0799	0875	095	1025	1101	75
577	76-	1176	1251	1326	1402	1477	1552	1627	1702	1778	1853	75
578	76-	1928	2003	2078	2153	2228	2303	2378	2453	2529	2604	75
579	76-	2679	2754	2829	2904	2978	3053	3128	3203	3278	3353	75
580	76-	3428	3503	3578	3653	3727	3802	3877	3952	4027	4101	75
581	76-	4176	4251	4326	44	4475	455	4624	4699	4774	4848	75
582	76-	4923	4998	5072	5147	5221	5296	537	5445	552	5594	75
583	76-	5669	5743	5818	5892	5966	6041	6115	619	6264	6338	74
584	76-	6413	6487	6562	6636	671	6785	6859	6933	7007	7082	74
585	76-	7156	723	7304	7379	7453	7527	7601	7675	7749	7823	74
586	76-	7898	7972	8046	812	8194	8268	8342	8416	849	8564	74
587	76-	8638	8712	8786	886	8934	9008	9082	9156	923	9303	74
588	76-	9377	9451	9525	9599	9673	9746	982	9894	9968	—	74
588	77-	—	—	—	—	—	—	—	—	—	0042	74
589	77-	0115	0189	0263	0336	041	0484	0557	0631	0705	0778	74
590	77-	0852	0926	0999	1073	1146	122	1293	1367	144	1514	74
591	77-	1587	1661	1734	1808	1881	1955	2028	2102	2175	2248	73
592	77-	2322	2395	2468	2542	2615	2688	2762	2835	2908	2981	73
593	77-	3055	3128	3201	3274	3348	3421	3494	3567	364	3713	73
594	77-	3786	386	3933	4006	4079	4152	4225	4298	4371	4444	73
595	77-	4517	459	4663	4736	4809	4882	4955	5028	51	5173	73
596	77-	5246	5319	5392	5465	5538	561	5683	5756	5829	5902	73
597	77-	5974	6047	612	6193	6265	6338	6411	6483	6556	6629	73
598	77-	6701	6774	6846	6919	6992	7064	7137	7209	7282	7354	73
599	77-	7427	7499	7572	7644	7717	7789	7862	7934	8006	8079	72
600	77-	8151	8224	8296	8368	8441	8513	8585	8658	873	8802	72
601	77-	8874	8947	9019	9091	9163	9236	9308	938	9452	9524	72
602	77-	9596	9669	9741	9813	9885	9957	—	—	—	—	72
602	78-	—	—	—	—	—	—	0029	0101	0173	0245	72
603	78-	0317	0389	0461	0533	0605	0677	0749	0821	0893	0965	72
604	78-	1037	1109	1181	1253	1324	1396	1468	154	1612	1684	72
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605	78-	1755	1827	1899	1971	2042	2114	2186	2258	2329	2401	72
606	78-	2473	2544	2616	2688	2759	2831	2902	2974	3046	3117	72
607	78-	3189	326	3332	3403	3475	3546	3618	3689	3761	3832	71
608	78-	3904	3975	4046	4118	4189	4261	4332	4403	4475	4546	71
609	78-	4617	4689	476	4831	4902	4974	5045	5116	5187	5259	71
610	78-	533	5401	5472	5543	5615	5686	5757	5828	5899	597	71
611	78-	6041	6112	6183	6254	6325	6396	6467	6538	6609	668	71
612	78-	6751	6822	6893	6964	7035	7106	7177	7248	7319	739	71
613	78-	746	7531	7602	7673	7744	7815	7885	7956	8027	8098	71
614	78-	8168	8239	831	8381	8451	8522	8593	8663	8734	8804	71
615	78-	8875	8946	9016	9087	9157	9228	9299	9369	944	951	71
616	78-	9581	9651	9722	9792	9863	9933	—	—	—	—	70
616	79-	—	—	—	—	—	—	0004	0074	0144	0215	70
617	79-	0285	0356	0426	0496	0567	0637	0707	0778	0848	0918	70
618	79-	0988	1059	1129	1199	1269	134	141	148	155	162	70
619	79-	1691	1761	1831	1901	1971	2041	2111	2181	2252	2322	70
620	79-	2392	2462	2532	2602	2672	2742	2812	2882	2952	3022	70
621	79-	3092	3162	3231	3301	3371	3441	3511	3581	3651	3721	70
622	79-	379	386	393	4	407	4139	4209	4279	4349	4418	70
623	79-	4488	4558	4627	4697	4767	4836	4906	4976	5045	5115	70
624	79-	5185	5254	5324	5393	5463	5532	5602	5672	5741	5811	70
625	79-	588	5949	6019	6088	6158	6227	6297	6366	6436	6505	69
626	79-	6574	6644	6713	6782	6852	6921	699	706	7129	7198	69
627	79-	7268	7337	7406	7475	7545	7614	7683	7752	7821	789	69
628	79-	796	8029	8098	8167	8236	8305	8374	8443	8513	8582	69
629	79-	8651	872	8789	8858	8927	8996	9065	9134	9203	9272	69
630	79-	9341	9409	9478	9547	9616	9685	9754	9823	9892	9961	69
631	80-	0029	0098	0167	0236	0305	0373	0442	0511	058	0648	69
632	80-	0717	0786	0854	0923	0992	1061	1129	1198	1266	1335	69
633	80-	1404	1472	1541	1609	1678	1747	1815	1884	1952	2021	69
634	80-	2089	2158	2226	2295	2363	2432	25	2568	2637	2705	69
635	80-	2774	2842	291	2979	3047	3116	3184	3252	3321	3389	68
636	80-	3457	3525	3594	3662	373	3798	3867	3935	4003	4071	68
637	80-	4139	4208	4276	4344	4412	448	4548	4616	4685	4753	68
638	80-	4821	4889	4957	5025	5093	5161	5229	5297	5365	5433	68
639	80-	5501	5569	5637	5705	5773	5841	5908	5976	6044	6112	68
640	80-	618	6248	6316	6384	6451	6519	6587	6655	6723	679	68
641	80-	6858	6926	6994	7061	7129	7197	7264	7332	74	7467	68
642	80-	7535	7603	767	7738	7806	7873	7941	8008	8076	8143	68
643	80-	8211	8279	8346	8414	8481	8549	8616	8684	8751	8818	67
644	80-	8886	8953	9021	9088	9156	9223	929	9358	9425	9492	67
645	80-	956	9627	9694	9762	9829	9896	9964	—	—	—	67
645	81-	—	—	—	—	—	—	—	0031	0098	0165	67
646	81-	0233	03	0367	0434	0501	0569	0636	0703	077	0837	67
647	81-	0904	0971	1039	1106	1173	124	1307	1374	1441	1508	67
648	81-	1575	1642	1709	1776	1843	191	1977	2044	2111	2178	67
649	81-	2245	2312	2379	2445	2512	2579	2646	2713	278	2847	67
650	81-	2913	298	3047	3114	3181	3247	3314	3381	3448	3514	67
651	81-	3581	3648	3714	3781	3848	3914	3981	4048	4114	4181	67
652	81-	4248	4314	4381	4447	4514	4581	4647	4714	478	4847	67
653	81-	4913	498	5046	5113	5179	5246	5312	5378	5445	5511	66
654	81-	5578	5644	5711	5777	5843	591	5976	6042	6109	6175	66
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655	81-	6241	6308	6374	644	6506	6573	6639	6705	6771	6838	66
656	81-	6904	697	7036	7102	7169	7235	7301	7367	7433	7499	66
657	81-	7565	7631	7698	7764	783	7896	7962	8028	8094	816	66
658	81-	8226	8292	8358	8424	849	8556	8622	8688	8754	882	66
659	81-	8885	8951	9017	9083	9149	9215	9281	9346	9412	9478	66
660	81-	9544	961	9676	9741	9807	9873	9939	—	—	—	66
660	82-	—	—	—	—	—	—	—	0004	007	0136	66
661	82-	0201	0267	0333	0399	0464	053	0595	0661	0727	0792	66
662	82-	0858	0924	0989	1055	112	1186	1251	1317	1382	1448	66
663	82-	1514	1579	1645	171	1775	1841	1906	1972	2037	2103	65
664	82-	2168	2233	2299	2364	243	2495	256	2626	2691	2756	65
665	82-	2822	2887	2952	3018	3083	3148	3213	3279	3344	3409	65
666	82-	3474	3539	3605	367	3735	38	3865	393	3996	4061	65
667	82-	4126	4191	4256	4321	4386	4451	4516	4581	4646	4711	65
668	82-	4776	4841	4906	4971	5036	5101	5166	5231	5296	5361	65
669	82-	5426	5491	5556	5621	5686	5751	5815	588	5945	601	65
670	82-	6075	614	6204	6269	6334	6399	6464	6528	6593	6658	65
671	82-	6723	6787	6852	6917	6981	7046	7111	7175	724	7305	65
672	82-	7369	7434	7499	7563	7628	7692	7757	7821	7886	7951	65
673	82-	8015	808	8144	8209	8273	8338	8402	8467	8531	8595	64
674	82-	866	8724	8789	8853	8918	8982	9046	9111	9175	9239	64
675	82-	9304	9368	9432	9497	9561	9625	969	9754	9818	9882	64
676	82-	9947	—	—	—	—	—	—	—	—	—	64
676	83-	—	0011	0075	0139	0204	0268	0332	0396	046	0525	64
677	83-	0589	0653	0717	0781	0845	0909	0973	1037	1102	1166	64
678	83-	123	1294	1358	1422	1486	155	1614	1678	1742	1806	64
679	83-	187	1934	1998	2062	2126	2189	2253	2317	2381	2445	64
680	83-	2509	2573	2637	27	2764	2828	2892	2956	302	3083	64
681	83-	3147	3211	3275	3338	3402	3466	353	3593	3657	3721	64
682	83-	3784	3848	3912	3975	4039	4103	4166	423	4294	4357	64
683	83-	4421	4484	4548	4611	4675	4739	4802	4866	4929	4993	64
684	83-	5056	512	5183	5247	531	5373	5437	55	5564	5627	63
685	83-	5691	5754	5817	5881	5944	6007	6071	6134	6197	6261	63
686	83-	6324	6387	6451	6514	6577	6641	6704	6767	683	6894	63
687	83-	6957	702	7083	7146	721	7273	7336	7399	7462	7525	63
688	83-	7588	7652	7715	7778	7841	7904	7967	803	8093	8156	63
689	83-	8219	8282	8345	8408	8471	8534	8597	866	8723	8786	63
690	83-	8849	8912	8975	9038	9101	9164	9227	9289	9352	9415	63
691	83-	9478	9541	9604	9667	9729	9792	9855	9918	9981	—	63
691	84-	—	—	—	—	—	—	—	—	—	0043	63
692	84	0106	0169	0232	0294	0357	042	0482	0545	0608	0671	63
693	84-	0733	0796	0859	0921	0984	1046	1109	1172	1234	1297	63
694	84-	1359	1422	1485	1547	161	1672	1735	1797	186	1922	63
695	84-	1985	2047	211	2172	2235	2297	236	2422	2484	2547	62
696	84-	2609	2672	2734	2796	2859	2921	2983	3046	3108	317	62
697	84-	3233	3295	3357	342	3482	3544	3606	3669	3731	3793	62
698	84-	3855	3918	398	4042	4104	4166	4229	4291	4353	4415	62
699	84-	4477	4539	4601	4664	4726	4788	485	4912	4974	5036	62
700	84-	5098	516	5222	5284	5346	5408	547	5532	5594	5656	62
701	84-	5718	578	5842	5904	5966	6028	609	6151	6213	6275	62
702	84-	6337	6399	6461	6523	6585	6646	6708	677	6832	6894	62
703	84-	6955	7017	7079	7141	7202	7264	7326	7388	7449	7511	62
704	84-	7573	7634	7696	7758	7819	7881	7943	8004	8066	8127	62
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705	84-	8189	8251	8312	8374	8435	8497	8559	862	8682	8743	62
706	84-	8805	8866	8928	8989	9051	9112	9174	9235	9297	9358	61
707	84-	9419	9481	9542	9604	9665	9726	9788	9849	9911	9972	61
708	85-	0033	0095	0156	0217	0279	034	0401	0462	0524	0585	61
709	85-	0646	0707	0769	083	0891	0952	1014	1075	1136	1197	61
710	85-	1258	132	1381	1442	1503	1564	1625	1686	1747	1809	61
711	85-	187	1931	1992	2053	2114	2175	2236	2297	2358	2419	61
712	85-	248	2541	2602	2663	2724	2785	2846	2907	2968	3029	61
713	85-	309	315	3211	3272	3333	3394	3455	3516	3577	3637	61
714	85-	3698	3759	382	3881	3941	4002	4063	4124	4185	4245	61
715	85-	4306	4367	4428	4488	4549	461	467	4731	4792	4852	61
716	85-	4913	4974	5034	5095	5156	5216	5277	5337	5398	5459	61
717	85-	5519	558	564	5701	5761	5822	5882	5943	6003	6064	61
718	85-	6124	6185	6245	6306	6366	6427	6487	6548	6608	6668	60
719	85-	6729	6789	685	691	697	7031	7091	7152	7212	7272	60
720	85-	7332	7393	7453	7513	7574	7634	7694	7755	7815	7875	60
721	85-	7935	7995	8056	8116	8176	8236	8297	8357	8417	8477	60
722	85-	8537	8597	8657	8718	8778	8838	8898	8958	9018	9078	60
723	85-	9138	9198	9258	9318	9379	9439	9499	9559	9619	9679	60
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727	86-	1534	1594	1654	1714	1773	1833	1893	1952	2012	2072	60
728	86-	2131	2191	2251	231	237	243	2489	2549	2608	2668	60
729	86-	2728	2787	2847	2906	2966	3025	3085	3144	3204	3263	60
730	86-	3323	3382	3442	3501	3561	362	368	3739	3799	3858	59
731	86-	3917	3977	4036	4096	4155	4214	4274	4333	4392	4452	59
732	86-	4511	457	463	4689	4748	4808	4867	4926	4985	5045	59
733	86-	5104	5163	5222	5282	5341	54	5459	5519	5578	5637	59
734	86-	5696	5755	5814	5874	5933	5992	6051	611	6169	6228	59
735	86-	6287	6346	6405	6465	6524	6583	6642	6701	676	6819	59
736	86-	6878	6937	6996	7055	7114	7173	7232	7291	735	7409	59
737	86-	7467	7526	7585	7644	7703	7762	7821	788	7939	7998	59
738	86-	8056	8115	8174	8233	8292	835	8409	8468	8527	8586	59
739	86-	8644	8703	8762	8821	8879	8938	8997	9056	9114	9173	59
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741	86-	9818	9877	9935	9994	—	—	—	—	—	—	59
741	87-	—	—	—	—	0053	0111	017	0228	0287	0345	59
742	87-	0404	0462	0521	0579	0638	0696	0755	0813	0872	093	58
743	87-	0989	1047	1106	1164	1223	1281	1339	1398	1456	1515	58
744	87-	1573	1631	169	1748	1806	1865	1923	1981	204	2098	58
745	87-	2156	2215	2273	2331	2389	2448	2506	2564	2622	2681	58
746	87-	2739	2797	2855	2913	2972	303	3088	3146	3204	3262	58
747	87-	3321	3379	3437	3495	3553	3611	3669	3727	3785	3844	58
748	87-	3902	396	4018	4076	4134	4192	425	4308	4366	4424	58
749	87-	4482	454	4598	4656	4714	4772	483	4888	4945	5003	58
750	87-	5061	5119	5177	5235	5293	5351	5409	5466	5524	5582	58
751	87-	564	5698	5756	5813	5871	5929	5987	6045	6102	616	58
752	87-	6218	6276	6333	6391	6449	6507	6564	6622	668	6737	58
753	87-	6795	6853	691	6968	7026	7083	7141	7199	7256	7314	58
754	87-	7371	7429	7487	7544	7602	7659	7717	7774	7832	7889	58
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756	87-	8522	8579	8637	8694	8752	8809	8866	8924	8981	9039	57
757	87-	9096	9153	9211	9268	9325	9383	944	9497	9555	9612	57
758	87-	9669	9726	9784	9841	9898	9956	—	—	—	—	57
758	88-	—	—	—	—	—	—	0013	007	0127	0185	57
759	88-	0242	0299	0356	0413	0471	0528	0585	0642	0699	0756	57
760	88-	0814	0871	0928	0985	1042	1099	1156	1213	1271	1328	57
761	88-	1385	1442	1499	1556	1613	167	1727	1784	1841	1898	57
762	88-	1955	2012	2069	2126	2183	224	2297	2354	2411	2468	57
763	88-	2525	2581	2638	2695	2752	2809	2866	2923	298	3037	57
764	88-	3093	315	3207	3264	3321	3377	3434	3491	3548	3605	57
765	88-	3661	3718	3775	3832	3888	3945	4002	4059	4115	4172	57
766	88-	4229	4285	4342	4399	4455	4512	4569	4625	4682	4739	57
767	88-	4795	4852	4909	4965	5022	5078	5135	5192	5248	5305	57
768	88-	5361	5418	5474	5531	5587	5644	57	5757	5813	587	57
769	88-	5926	5983	6039	6096	6152	6209	6265	6321	6378	6434	56
770	88-	6491	6547	6604	666	6716	6773	6829	6885	6942	6998	56
771	88-	7054	7111	7167	7223	728	7336	7392	7449	7505	7561	56
772	88-	7617	7674	773	7786	7842	7898	7955	8011	8067	8123	56
773	88-	8179	8236	8292	8348	8404	846	8516	8573	8629	8685	56
774	88-	8741	8797	8853	8909	8965	9021	9077	9134	919	9246	56
775	88-	9302	9358	9414	947	9526	9582	9638	9694	975	9806	56
776	88-	9862	9918	9974	—	—	—	—	—	—	—	56
776	89-	—	—	—	003	0086	0141	0197	0253	0309	0365	56
777	89-	0421	0477	0533	0589	0645	07	0756	0812	0868	0924	56
778	89-	098	1035	1091	1147	1203	1259	1314	137	1426	1482	56
779	89-	1537	1593	1649	1705	176	1816	1872	1928	1983	2039	56
780	89-	2095	215	2206	2262	2317	2373	2429	2484	254	2595	56
781	89-	2651	2707	2762	2818	2873	2929	2985	304	3096	3151	56
782	89-	3207	3262	3318	3373	3429	3484	354	3595	3651	3706	56
783	89-	3762	3817	3873	3928	3984	4039	4094	415	4205	4261	55
784	89-	4316	4371	4427	4482	4538	4593	4648	4704	4759	4814	55
785	89-	487	4925	498	5036	5091	5146	5201	5257	5312	5367	55
786	89-	5423	5478	5533	5588	5644	5699	5754	5809	5864	592	55
787	89-	5975	603	6085	614	6195	6251	6306	6361	6416	6471	55
788	89-	6526	6581	6636	6692	6747	6802	6857	6912	6967	7022	55
789	89-	7077	7132	7187	7242	7297	7352	7407	7462	7517	7572	55
790	89-	7627	7682	7737	7792	7847	7902	7957	8012	8067	8122	55
791	89-	8176	8231	8286	8341	8396	8451	8506	8561	8615	867	55
792	89-	8725	878	8835	889	8944	8999	9054	9109	9164	9218	55
793	89-	9273	9328	9383	9437	9492	9547	9602	9656	9711	9766	55
794	89-	9821	9875	993	9985	—	—	—	—	—	—	55
794	90-	—	—	—	—	0039	0094	0149	0203	0258	0312	55
795	90-	0367	0422	0476	0531	0586	064	0695	0749	0804	0859	55
796	90-	0913	0968	1022	1077	1131	1186	124	1295	1349	1404	55
797	90-	1458	1513	1567	1622	1676	1731	1785	184	1894	1948	54
798	90-	2003	2057	2112	2166	2221	2275	2329	2384	2438	2492	54
799	90-	2547	2601	2655	271	2764	2818	2873	2927	2981	3036	54
800	90-	309	3144	3199	3253	3307	3361	3416	347	3524	3578	54
801	90-	3633	3687	3741	3795	3849	3904	3958	4012	4066	412	54
802	90-	4174	4229	4283	4337	4391	4445	4499	4553	4607	4661	54
803	90-	4716	477	4824	4878	4932	4986	504	5094	5148	5202	54
804	90-	5256	531	5364	5418	5472	5526	558	5634	5688	5742	54
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805	90-	5796	585	5904	5958	6012	6066	6119	6173	6227	6281	54
806	90-	6335	6389	6443	6497	6551	6604	6658	6712	6766	682	54
807	90-	6874	6927	6981	7035	7089	7143	7196	725	7304	7358	54
808	90-	7411	7465	7519	7573	7626	768	7734	7787	7841	7895	54
809	90-	7949	8002	8056	811	8163	8217	827	8324	8378	8431	54
810	90-	8485	8539	8592	8646	8699	8753	8807	886	8914	8967	54
811	90-	9021	9074	9128	9181	9235	9289	9342	9396	9449	9503	54
812	90-	9556	9609	9663	9716	977	9823	9877	993	9984	—	54
812	91-	—	—	—	—	—	—	—	—	—	0037	53
813	91-	0091	0144	0197	0251	0304	0358	0411	0464	0518	0571	53
814	91-	0624	0678	0731	0784	0838	0891	0944	0998	1051	1104	53
815	91-	1158	1211	1264	1317	1371	1424	1477	153	1584	1637	53
816	91-	169	1743	1797	185	1903	1956	2009	2063	2116	2169	53
817	91-	2222	2275	2328	2381	2435	2488	2541	2594	2647	27	53
818	91-	2753	2806	2859	2913	2966	3019	3072	3125	3178	3231	53
819	91-	3284	3337	339	3443	3496	3549	3602	3655	3708	3761	53
820	91-	3814	3867	392	3973	4026	4079	4132	4184	4237	429	53
821	91-	4343	4396	4449	4502	4555	4608	466	4713	4766	4819	53
822	91-	4872	4925	4977	503	5083	5136	5189	5241	5294	5347	53
823	91-	54	5453	5505	5558	5611	5664	5716	5769	5822	5875	53
824	91-	5927	598	6033	6085	6138	6191	6243	6296	6349	6401	53
825	91-	6454	6507	6559	6612	6664	6717	677	6822	6875	6927	53
826	91-	698	7033	7085	7138	719	7243	7295	7348	74	7453	53
827	91-	7506	7558	7611	7663	7716	7768	782	7873	7925	7978	52
828	91-	803	8083	8135	8188	824	8293	8345	8397	845	8502	52
829	91-	8555	8607	8659	8712	8764	8816	8869	8921	8973	9026	52
830	91-	9078	913	9183	9235	9287	934	9392	9444	9496	9549	52
831	91-	9601	9653	9706	9758	981	9862	9914	9967	—	—	52
831	92-	—	—	—	—	—	—	—	—	0019	0071	52
832	92-	0123	0176	0228	028	0332	0384	0436	0489	0541	0593	52
833	92-	0645	0697	0749	0801	0853	0906	0958	101	1062	1114	52
834	92-	1166	1218	127	1322	1374	1426	1478	153	1582	1634	52
835	92-	1686	1738	179	1842	1894	1946	1998	205	2102	2154	52
836	92-	2206	2258	231	2362	2414	2466	2518	257	2622	2674	52
837	92-	2725	2777	2829	2881	2933	2985	3037	3089	314	3192	52
838	92-	3244	3296	3348	3399	3451	3503	3555	3607	3658	371	52
839	92-	3762	3814	3865	3917	3969	4021	4072	4124	4176	4228	52
840	92-	4279	4331	4383	4434	4486	4538	4589	4641	4693	4744	52
841	92-	4796	4848	4899	4951	5003	5054	5106	5157	5209	5261	52
842	92-	5312	5364	5415	5467	5518	557	5621	5673	5725	5776	52
843	92-	5828	5879	5931	5982	6034	6085	6137	6188	624	6291	51
844	92-	6342	6394	6445	6497	6548	66	6651	6702	6754	6805	51
845	92-	6857	6908	6959	7011	7062	7114	7165	7216	7268	7319	51
846	92-	737	7422	7473	7524	7576	7627	7678	773	7781	7832	51
847	92-	7883	7935	7986	8037	8088	814	8191	8242	8293	8345	51
848	92-	8396	8447	8498	8549	8601	8652	8703	8754	8805	8857	51
849	92-	8908	8959	901	9061	9112	9163	9215	9266	9317	9368	51
850	92-	9419	947	9521	9572	9623	9674	9725	9776	9827	9879	51
851	92-	993	9981	—	—	—	—	—	—	—	—	51
851	93-	—	—	0032	0083	0134	0185	0236	0287	0338	0389	51
852	93-	044	0491	0542	0592	0643	0694	0745	0796	0847	0898	51
853	93-	0949	1	1051	1102	1153	1203	1254	1305	1356	1407	51
854	93-	1458	1509	156	161	1661	1712	1763	1814	1865	1915	51
No		0	1	2	3	4	5	6	7	8	9	

No.	0	1	2	3	4	5	6	7	8	9	D
855	93- 1966	2017	2068	2118	2169	222	2271	2322	2372	2423	51
856	93- 2474	2524	2575	2626	2677	2727	2778	2829	2879	293	51
857	93- 2981	3031	3082	3133	3183	3234	3285	3335	3386	3437	51
858	93- 3487	3538	3589	3639	369	374	3791	3841	3892	3943	51
859	93- 3993	4044	4094	4145	4195	4246	4296	4347	4397	4448	51
860	93- 4498	4549	4599	465	47	4751	4801	4852	4902	4953	50
861	93- 5003	5054	5104	5154	5205	5255	5306	5356	5406	5457	50
862	93- 5507	5558	5608	5658	5709	5759	5809	586	591	596	50
863	93- 6011	6061	6111	6162	6212	6262	6313	6363	6413	6463	50
864	93- 6514	6564	6614	6665	6715	6765	6815	6865	6916	6966	50
865	93- 7016	7066	7117	7167	7217	7267	7317	7367	7418	7468	50
866	93- 7518	7568	7618	7668	7718	7769	7819	7869	7919	7969	50
867	93- 8019	8069	8119	8169	8219	8269	8319	837	842	847	50
868	93- 852	857	862	867	872	877	882	887	892	897	50
869	93- 902	907	912	917	922	927	932	9369	9419	9469	50
870	93- 9519	9569	9619	9669	9719	9769	9819	9869	9918	9968	50
871	94- 0018	0068	0118	0168	0218	0267	0317	0367	0417	0467	50
872	94- 0516	0566	0616	0666	0716	0765	0815	0865	0915	0964	50
873	94- 1014	1064	1114	1163	1213	1263	1313	1362	1412	1462	50
874	94- 1511	1561	1611	166	171	176	1809	1859	1909	1958	50
875	94- 2008	2058	2107	2157	2207	2256	2306	2355	2405	2455	50
876	94- 2504	2554	2603	2653	2702	2752	2801	2851	2901	295	50
877	94- 3	3049	3099	3148	3198	3247	3297	3346	3396	3445	49
878	94- 3495	3544	3593	3643	3692	3742	3791	3841	389	3939	49
879	94- 3989	4038	4088	4137	4186	4236	4285	4335	4384	4433	49
880	94- 4483	4532	4581	4631	468	4729	4779	4828	4877	4927	49
881	94- 4976	5025	5074	5124	5173	5222	5272	5321	537	5419	49
882	94- 5469	5518	5567	5616	5665	5715	5764	5813	5862	5912	49
883	94- 5961	601	6059	6108	6157	6207	6256	6305	6354	6403	49
884	94- 6452	6501	6551	66	6649	6698	6747	6796	6845	6894	49
885	94- 6943	6992	7041	709	714	7189	7238	7287	7336	7385	49
886	94- 7434	7483	7532	7581	763	7679	7728	7777	7826	7875	49
887	94- 7924	7973	8022	807	8119	8168	8217	8266	8315	8364	49
888	94- 8413	8462	8511	856	8609	8657	8706	8755	8804	8853	49
889	94- 8902	8951	8999	9048	9097	9146	9195	9244	9292	9341	49
800	94- 939	9439	9488	9536	9585	9634	9683	9731	978	9829	49
891	94- 9878	9926	9975	—	—	—	—	—	—	—	49
891	95- —	—	—	0024	0073	0121	017	0219	0267	0316	49
892	95- 0365	0414	0462	0511	056	0608	0657	0706	0754	0803	49
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894	95- 1338	1386	1435	1483	1532	158	1629	1677	1726	1775	49
895	95- 1823	1872	192	1969	2017	2066	2114	2163	2211	226	48
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898	95- 3276	3325	3373	3421	347	3518	3566	3615	3663	3711	48
899	95- 376	3808	3856	3905	3953	4001	4049	4098	4146	4194	48
900	95- 4243	4291	4339	4387	4435	4484	4532	458	4628	4677	48
901	95- 4725	4773	4821	4869	4918	4966	5014	5062	511	5158	48
902	95- 5207	5255	5303	5351	5399	5447	5495	5543	5592	564	48
903	95- 5688	5736	5784	5832	588	5928	5976	6024	6072	612	48
904	95- 6168	6216	6265	6313	6361	6409	6457	6505	6553	6601	48
No.	0	1	2	3	4	5	6	7	8	9	D

No.		0	1	2	3	4	5	6	7	8	9	D
905	95-	6649	6697	6745	6793	684	6888	6936	6984	7032	708	48
906	95-	7128	7176	7224	7272	732	7368	7416	7464	7512	7559	48
907	95-	7607	7655	7703	7751	7799	7847	7894	7942	799	8038	48
908	95-	8086	8134	8181	8229	8277	8325	8373	8421	8468	8516	48
909	95-	8564	8612	8659	8707	8755	8803	885	8898	8946	8994	48
910	95-	9041	9089	9137	9185	9232	928	9328	9375	9423	9471	48
911	95-	9518	9566	9614	9661	9709	9757	9804	9852	99	9947	48
912	95-	9995	—	—	—	—	—	—	—	—	—	48
912	96-	—	0042	009	0138	0185	0233	028	0328	0376	0423	48
913	96-	0471	0518	0566	0613	0661	0709	0756	0804	0851	0899	48
914	96-	0946	0994	1041	1089	1136	1184	1231	1279	1326	1374	47
915	96-	1421	1469	1516	1563	1611	1658	1706	1753	1801	1848	47
916	96-	1895	1943	199	2038	2085	2132	218	2227	2275	2322	47
917	96-	2369	2417	2464	2511	2559	2606	2653	2701	2748	2795	47
918	96-	2843	289	2937	2985	3032	3079	3126	3174	3221	3268	47
919	96-	3316	3363	341	3457	3504	3552	3599	3646	3693	3741	47
920	96-	3788	3835	3882	3929	3977	4024	4071	4118	4165	4212	47
921	96-	426	4307	4354	4401	4448	4495	4542	459	4637	4684	47
922	96-	4731	4778	4825	4872	4919	4966	5013	5061	5108	5155	47
923	96-	5202	5249	5296	5343	539	5437	5484	5531	5578	5625	47
924	96-	5672	5719	5766	5813	586	5907	5954	6001	6048	6095	47
925	96-	6142	6189	6236	6283	6329	6376	6423	647	6517	6564	47
926	96-	6611	6658	6705	6752	6799	6845	6892	6939	6986	7033	47
927	96-	708	7127	7173	722	7267	7314	7361	7408	7454	7501	47
928	96-	7548	7595	7642	7688	7735	7782	7829	7875	7922	7969	47
929	96-	8016	8062	8109	8156	8203	8249	8296	8343	839	8436	47
930	96-	8483	853	8576	8623	867	8716	8763	881	8856	8903	47
931	96-	895	8996	9043	909	9136	9183	9229	9276	9323	9369	47
932	96-	9416	9463	9509	9556	9602	9649	9695	9742	9789	9835	47
933	96-	9882	9928	9975	—	—	—	—	—	—	—	47
933	97-	—	—	—	0021	0068	0114	0161	0207	0254	03	47
934	97-	0347	0393	044	0486	0533	0579	0626	0672	0719	0765	46
935	97-	0812	0858	0904	0951	0997	1044	109	1137	1183	1229	46
936	97-	1276	1322	1369	1415	1461	1508	1554	1601	1647	1693	46
937	97-	174	1786	1832	1879	1925	1971	2018	2064	211	2157	46
938	97-	2203	2249	2295	2342	2388	2434	2481	2527	2573	2619	46
939	97-	2666	2712	2758	2804	2851	2897	2943	2989	3035	3082	46
940	97-	3128	3174	322	3266	3313	3359	3405	3451	3497	3543	46
941	97-	359	3636	3682	3728	3774	382	3866	3913	3959	4005	46
942	97-	4051	4097	4143	4189	4235	4281	4327	4374	442	4466	46
943	97-	4512	4558	4604	465	4696	4742	4788	4834	488	4926	46
944	97-	4972	5018	5064	511	5156	5202	5248	5294	534	5386	46
945	97-	5432	5478	5524	557	5616	5662	5707	5753	5799	5845	46
946	97-	5891	5937	5983	6029	6075	6121	6167	6212	6258	6304	46
947	97-	635	6396	6442	6488	6533	6579	6625	6671	6717	6763	46
948	97-	6808	6854	69	6946	6992	7037	7083	7129	7175	722	46
949	97-	7266	7312	7358	7403	7449	7495	7541	7586	7632	7678	46
950	97-	7724	7769	7815	7861	7906	7952	7998	8043	8089	8135	46
951	97-	8181	8226	8272	8317	8363	8409	8454	85	8546	8591	46
952	97-	8637	8683	8728	8774	8819	8865	8911	8956	9002	9047	46
953	*97-*	*9093*	*9138*	9184	923	9275	9321	9366	9412	9457	9503	46
954	*97-*	*9548*	9594	9639	9685	973	9776	9821	9867	9912	9958	46
No.		*0*	*1*	2	3	4	5	6	7	8	9	

No.	0	1	2	3	4	5	6	7	8	9	D
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956	98- 0458	0503	0549	0594	064	0685	073	0776	0821	0867	45
957	98- 0912	0957	1003	1048	1093	1139	1184	1229	1275	132	45
958	98- 1366	1411	1456	1501	1547	1592	1637	1683	1728	1773	45
959	98- 1819	1864	1909	1954	2	2045	209	2135	2181	2226	45
960	98- 2271	2316	2362	2407	2452	2497	2543	2588	2633	2678	45
961	98- 2723	2769	2814	2859	2904	2949	2994	304	3085	313	45
962	98- 3175	322	3265	331	3356	3401	3446	3491	3536	3581	45
963	98- 3626	3671	3716	3762	3807	3852	3897	3942	3987	4032	45
964	98- 4077	4122	4167	4212	4257	4302	4347	4392	4437	4482	45
965	98- 4527	4572	4617	4662	4707	4752	4797	4842	4887	4932	45
966	98- 4977	5022	5067	5112	5157	5202	5247	5292	5337	5382	45
967	98- 5426	5471	5516	5561	5606	5651	5696	5741	5786	583	45
968	98- 5875	592	5965	601	6055	61	6144	6189	6234	6279	45
969	98- 6324	6369	6413	6458	6503	6548	6593	6637	6682	6727	45
970	98- 6772	6817	6861	6906	6951	6996	704	7085	713	7175	45
971	98- 7219	7264	7309	7353	7398	7443	7488	7532	7577	7622	45
972	98- 7666	7711	7756	78	7845	789	7934	7979	8024	8068	45
973	98- 8113	8157	8202	8247	8291	8336	8381	8425	847	8514	45
974	98- 8559	8604	8648	8693	8737	8782	8826	8871	8916	896	45
975	98- 9005	9049	9094	9138	9183	9227	9272	9316	9361	9405	45
976	98- 945	9494	9539	9583	9628	9672	9717	9761	9806	985	44
977	98- 9895	9939	9983	—	—	—	—	—	—	—	44
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980	99- 1226	127	1315	1359	1403	1448	1492	1536	158	1625	44
981	99- 1669	1713	1758	1802	1846	189	1935	1979	2023	2067	44
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985	99- 3436	348	3524	3568	3613	3657	3701	3745	3789	3833	44
986	99- 3877	3921	3965	4009	4053	4097	4141	4185	4229	4273	44
987	99- 4317	4361	4405	4449	4493	4537	4581	4625	4669	4713	44
988	99- 4757	4801	4845	4889	4933	4977	5021	5065	5108	5152	44
989	99- 5196	524	5284	5328	5372	5416	546	5504	5547	5591	44
990	99- 5635	5679	5723	5767	5811	5854	5898	5942	5986	603	44
991	99- 6074	6117	6161	6205	6249	6293	6337	638	6424	6468	44
992	99- 6512	6555	6599	6643	6687	6731	6774	6818	6862	6906	44
993	99- 6949	6993	7037	708	7124	7168	7212	7255	7299	7343	44
994	99- 7386	743	7474	7517	7561	7605	7648	7692	7736	7779	44
995	99- 7823	7867	791	7954	7998	8041	8085	8129	8172	8216	44
996	99- 8259	8303	8347	839	8434	8477	8521	8564	8608	8652	44
997	99- 8695	8739	8782	8826	8869	8913	8956	9	9043	9087	44
998	99- 9131	9174	9218	9261	9305	9348	9392	9435	9479	9522	44
999	99- 9565	9609	9652	9696	9739	9783	9826	987	9913	9957	43
No.	0	1	2	3	4	5	6	7	8	9	D

[redacted]

ALGEBRA.

In arithmetic figures are used to express quantities. In Algebra quantities of every kind are denoted by the characters of the alphabet. The first letters of the alphabet, a, b, c, etc., are used to denote known quantities, while unknown quantities, or those which are to be found by calculation, are represented by the last letters, v, x, y, etc.

The signs in algebra have the same meaning as in arithmetic. $a + b$ is read "a plus b," and means that the two quantities are to be added. $a - b$ is read, "a minus b," and means b is to be subtracted from a. $a \times b$ is read, "a times b," and means that a is to be multiplied by b. This may also be expressed in the following way: $a \times b$, or generally, ab; $abc = a \times b \times c$; $\frac{a}{b} = a \div b$, means that a is to be divided by b.

Quantities having the sign $+$ prefixed are called "positive." Those having the sign $-$ are called "negative." When no sign is prefixed to a quantity it is always understood to be $+$ or positive.

The sign of equality is $=$, as in arithmetic. $a + b = c$, $a = b$, $\frac{a}{b} = d$, $ab = c$, are "algebraic equations."

The part on the left side of the sign of equality is called the "first *member" of the equation*; the part on the right side is

called the "second member." The parts of each member connected by $+$ or $-$ are called "terms."

Parenthesis is used to denote that several terms are to be considered as one. $(a + b)d$ means that the sum of $a + b$ is to be multiplied by d. $(a + b - c)d$ shows that a and b are to be added, c subtracted from the sum, and the remainder multiplied by d. Thus, if in the equation $(a + b - c)d = f$, a should be $= 5$, $b = 3$, $c = 2$, $d = 4$, the equation would be $(5 + 3 - 2)4 = f$, or $f = 24$. Instead of a parenthesis, a straight line over the terms is sometimes used, thus $(a + b)c$, or $\overline{a + b} \times c$.

A number prefixed to a letter is called a "numerical coefficient." $3a$ signifies that a is to be taken 3 times, or $a + a + a$. $2ab$ signifies $ab + ab$.

If a quantity is to be multiplied several times by itself, a small figure, called an "exponent," is placed a little above and at the right of the quantity. Thus, a^3 means $a \times a \times a$; a^2 is called the "second power," or the "square" of a. b^3 or $b \times b \times b$ is the "third power" or "cube" of b. d^4 is the fourth power of d, etc. (See also Arithmetic—Involution.)

A "root" of a quantity is one of the equal factors, the product of which is equal to the quantity. 2 is a root of 4, because $4 = 2 \times 2$. 2 is also a root of 8, 16, 32, etc., because these numbers can be produced by multiplying 2 by itself 3, 4, 5, etc., times. a is a root of a^2, because $a^2 = a \times a$. a is also a root of a^3, a^4, a^5, etc. Roots are named from the number of times they must be taken to produce the given quantity. Thus, if the factors are taken twice each is a second root, or "square root." 3 is the square root of 9, b is the square root of b^2. If the factors are taken three times, each is a third root, or "cube root." 4 is the cube root of 64, because $4 \times 4 \times 4 = 64$; a is the cube root of a^3.

The sign of root or the radical sign is $\sqrt{\ }$ thus $\sqrt{4} = 2$, $\sqrt[3]{27} = 3$. When no index is written over the radical sign, the square root is understood. $\sqrt{a^2}$ stands for $\sqrt[2]{a^2}$ and is equal to a. $\sqrt[4]{a^4} = a$. (See also Arithmetic—Evolution.)

The sign $>$ means "bigger than," the sign $<$ means "smaller than."

EQUATIONS.

An equation is an expression of equality between numbers or quantities. In an equation there may be one or more unknown quantities connected by algebraical signs with one or more known quantities. To solve an equation means to find all such values of the unknown quantities as will make the two members of the equation identical, if substituted for the unknown quantities in such equation.

The degree of an equation is determined by the powers, or number of factors, of unknown quantities contained in any term. Thus $x + a = b$, $x + a = b^2 - 3x$, are equations of the first degree, or "simple equations." $x^2 = a$, $x^2 + 2x + 3 = 7$, are equations of the second degree, or "quadratic equations." $x^3 = 27$, $x^3 + 2x^2 + x + b = c + 3d$ are equations of the third degree, or "cubic equations."

SIMPLE EQUATIONS.

To solve a simple equation we make use of the following principles:

1. The same quantity may be added to, or subtracted from, both members of an equation without destroying their equality.
2. The two members of an equation may be multiplied or divided by the same quantity without destroying the equality.

Example: If $a + x = c + d$

then $a + x + b = c + d + b$

and $a + x - b = c + d - b$

and $2\,(a + x) = 2\,(c + d)$

and $\dfrac{a + x}{2} = \dfrac{c + d}{2}$

By means of these principles the unknown quantities can be brought together in one member of the equation, and all the known quantities in the other member.

Example: $7 + x = 12$. Subtract 7 from both members.

$$x = 12 - 7, \text{ or } x = 5.$$

It will be seen that a term may be transposed from one member of an equation to the other by changing its sign from + to −, or from − to +. The following rules are, therefore, obtained for *solving a simple equation:*

MENSURATION.

Mensuration treats of the measurement of lines, surfaces and volumes.

A "point" is that which has only position, but no magnitude.

A "line" is that which has only one dimension—that is, length, but neither breadth nor thickness. The lines we draw on paper are only symbols to represent the ideal lines.

A "straight" or "right" line is a continuous line, pursuing the same direction at all points.

A "curved" line is a line of which no portion is straight.

"Parallel" lines are lines having the same direction and an equal distance from each other at all points.

Fig. 1—Curved Line.

Fig. 2—Parallel Lines.

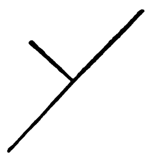


Fig. 3—Perpendicular Line.

An "horizontal" line is a line parallel to the water level or to the horizon.

A "perpendicular" line is a straight line meeting another straight line so as to incline no more to the one side than to the other.

Fig. 4—Vertical Line.

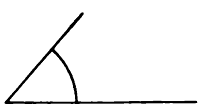


Fig. 5—Angle.

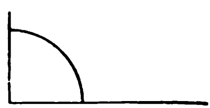


Fig. 6—Right Angle.

A "vertical" line is a straight line perpendicular to an horizontal line, or a line pointing to the center of the earth.

An "angle" is the difference in direction of two lines proceeding from one common point.

A "right" angle is formed by two lines perpendicular to each *other.*

An "acute" angle is an angle less than a right angle.

An "obtuse" angle is an angle greater than a right angle.

A "surface" is that which has two dimensions—that is, length and breadth.

A "plane" is a surface in which a straight line joining any two points of it will lie wholly in the surface.

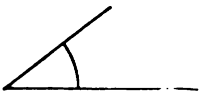


Fig. 7—Acute Angle.

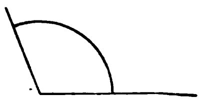


Fig. 8—Obtuse Angle

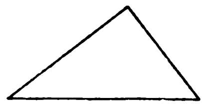


Fig. 9—Triangle

A "plane" figure is a part of a plane surface bounded by straight or curved lines.

The "area" of a plane figure is the surface included within the lines which bound it.

A "triangle" is a plane figure bounded by three sides, composed of straight lines, and having three angles.

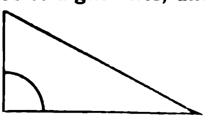


Fig. 10—Right-angled Triangle.

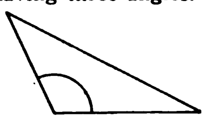


Fig. 11—Obtuse-angled Triangle.

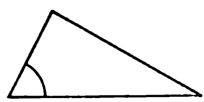


Fig. 12—Acute-angled Triangle.

A "right-angled" triangle has one right angle.

An "obtuse-angled" triangle has an obtuse angle.

An "acute-angled" triangle has all its angles acute.

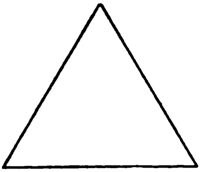


Fig. 13—Equilateral Triangle.

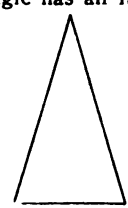


Fig. 14—Isosceles Triangle.

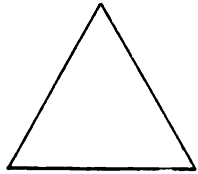


Fig. 15—Base of Triangle.

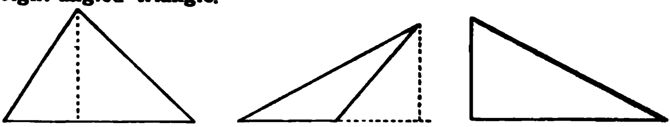
An "equilateral" triangle has all three sides of equal length.

An "isosceles" triangle has only two sides of equal length.

The *"base" of a triangle* is the side on which it is supposed *to rest.*

The "altitude" or "height" of a triangle is a straight line drawn perpendicular to the base from the angle opposite.

The "hypotenuse" is the side opposite the right angle in a right-angled triangle.



Figs. 16 and 17—Altitude or Height of a Triangle. Fig. 18—Hypotenuse.

The "cathetæ" are the two sides enclosing the right angle in a right-angled triangle.

MENSURATION OF AREAS.

To find the area of a triangle, multiply the base by the height and divide the product by 2.

Area = base $\times$ height $\div$ 2; Height = 2 $\times$ area $\div$ base; Base = 2 $\times$ area $\div$ height;

Example.—Area = $6 \times 10 \div 2 = 30$.

Height = $2 \times 30 \div 6 = 10$.

Base = $2 \times 30 \div 10 = 6$.

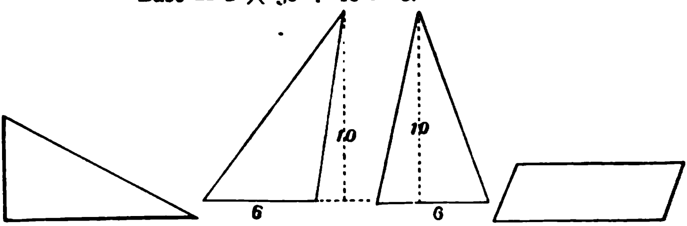


Fig. 19—Cathetae. Fig. 20—To find the area of a Triangle. Fig. 21—Parallelogram.

"Polygons" are plane figures, having three or more sides. They are regular, or irregular, according to whether their sides are of equal length or not; and are named from the number of their sides or angles. A "triangle" is a polygon of three sides or angles. A "quadrilateral" is a polygon of four sides or angles.

Quadrilaterals are divided as follows:

"Parallelogram," which is bounded by two pairs of parallel sides.

"Trapezoid," having two sides parallel.

"Trapezium," having no two sides parallel.

[redacted]

A parallelogram with right angles is called a "rectangle."

A rectangle whose sides are all equal is called a "square."

A "pentagon" has five sides. A "hexagon" has six sides. A "heptagon" has seven sides. An "octagon" has eight sides.


Fig. 22—Trapezoid.

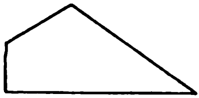


Fig. 23—Trapezium.


Fig. 24—Rectangle.

The "perimeter" is the boundary line or circumference of a plane figure.

To find the area of a parallelogram, multiply the base by the height, which is the perpendicular distance of the base from the parallel side opposite. Area $= ad \times h$.

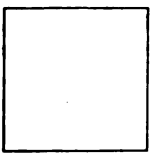


Fig. 25—Square.

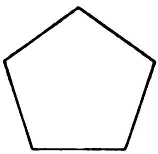


Fig. 26—Pentagon.

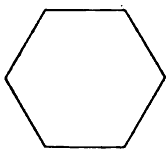


Fig. 27—Hexagon.

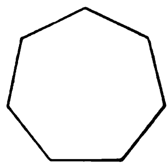


Fig. 28—Heptagon.

In a rectangle, the height is equal to the side which is perpendicular to the base. Hence, *to find the area of a rectangle,* multiply the length by the breadth or height. Area $= ad \times ab = ab \times bc$.

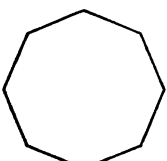


Fig. 29—Octagon.

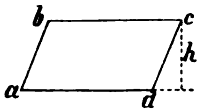


Fig. 30—To find the area of a Parallelogram.

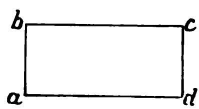


Fig. 31—To find the area of a Rectangle.

To find the area of a square, multiply the side by itself. Area $= ad^2 = ab^2 = bc^2 = cd^2$.

To find the area of a trapezoid, multiply the sum of the two parallel sides by the height or perpendicular distance between them, and divide the product by 2. Area $= (ad + bc)h \div 2$.

[redacted]

To find the area of a trapesium, **divide it into triangles by drawing a diagonal, which is a line connecting two points of the figure not connected by a single side. Multiply the diagonal by the sum of the two perpendiculars falling upon it from the** opposite angles, and divide the **product by 2. Area = ac (be + df) ÷ 2.**

To find the area of an irregular polygon, **divide the polygon into triangles and add the areas of the triangles. Area = A + B** + C. (See Fig. 35. page 62.)

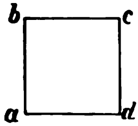


Fig. 32—To find the area of a Square.

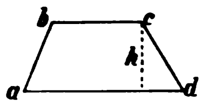


Fig 33—To find the area of a Trapezoid.

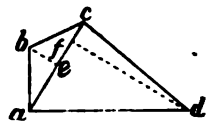


Fig. 34—To find the area of a Traperium.

To find the area of a regular polygon, multiply the length of a side by the perpendicular distance to the center, divide the product by 2, and multiply the quotient by the number of sides. (See Fig. 36.)

$$\text{Area} = \frac{\text{ab} \times \text{oc}}{2} \times 6.$$

ROUND FIGURES.—CIRCLE.

The "circle" is a plane figure bounded by a curved line, of which all points are at an equal distance from a point within called the *center.*

"Circumference" or "periphery" is the curved line which bounds the circle.

"Diameter" is a straight line passing through the center and intersecting the circumference on both sides, as abc. (Fig. 37.)

"Radius" is a straight line, extending from the center to any point on the circumference, and is one-half the diameter, as bd.

An "arc" of a circle is any part of its circumference, as cd.

A "chord" is any straight line joining two points of the circumference, as ed.

A "segment" is any part bounded by an arc and its chord, as A.

A "sector" is any part of a circle bounded by an arc and its *two radii, as B.*

A "semicircle" is half a circle.

[redacted]

DIAMETERS, CIRCUMFERENCES AND AREAS OF CIRCLES (1 TO 150 DIAMETER).

Diam.	Circum.	Area.	Diam.	Circum.	Area.	Diam.	Circum.	Area.
1	3.1416	0.7854	51	160.22	2042.82	101	317.30	8011.85
2	6.2832	3.1416	52	163.36	2123.72	102	320.44	8171.28
3	9.4248	7.0686	53	166.50	2206.18	103	323.58	8332.29
4	12.5664	12.5664	54	169.65	2290.22	104	326.73	8494.87
5	15.7080	19.635	55	172.79	2375.83	105	329.87	8659.01
6	18.850	28.274	56	175.93	2463.01	106	333.01	8824.73
7	21.991	38.485	57	179.07	2551.76	107	336.15	8992.02
8	25.133	50.266	58	182.21	2642.08	108	339.29	9160.88
9	28.274	63.617	59	185.35	2733.97	109	342.43	9331.32
10	31.416	78.540	60	188.50	2827.43	110	345.58	9503.32
11	34.558	95.033	61	191.64	2922.47	111	348.72	9676.89
12	37.699	113.10	62	194.78	3019.07	112	351.86	9852.03
13	40.841	132.73	63	197.92	3117.25	113	355.00	10028.75
14	43.982	153.94	64	201.06	3216.99	114	358.14	10207.03
15	47.124	176.71	65	204.20	3318.31	115	361.28	10386.89
16	50.265	201.06	66	207.34	3421.19	116	364.42	10568.32
17	53.407	226.98	67	210.49	3525.65	117	367.57	10751.32
18	56.549	254.47	68	213.63	3631.68	118	370.71	10935.88
19	59 690	283.53	69	216.77	3739.28	119	373.85	11122.02
20	62.832	314.16	70	219.91	3848.45	120	376.99	11309.73
21	65.973	346.36	71	223.05	3959.19	121	380.13	11499.01
22	69.115	380.13	72	226.19	4071.50	122	383.27	11689.87
23	72.257	415.48	73	229.34	4185.39	123	386.42	11882.29
24	75.398	452.39	74	232 48	4300.84	124	389.56	12076.28
25	78.540	490.87	75	235.62	4417.86	125	392.70	12271.85
26	81.681	530.93	76	238.76	4536.46	126	395.84	12468.98
27	84.823	572.56	77	241.90	4656.63	127	398.98	12667.69
28	87.965	615.75	78	245.04	4778.36	128	402.12	12867.96
29	91.106	660.52	79	248.19	4901.67	129	405.27	13069.81
30	94.248	706.86	80	251.33	5026.55	130	408.41	13273.23
31	97.389	754.77	81	251.47	5153.00	131	411.55	13478.22
32	100.53	804.25	82	257.61	5281.02	132	414.69	13684.78
33	103.67	855.30	83	260.75	5410.61	133	417.83	13892.91
34	106.81	907.92	84	263.89	5541.77	134	420.97	14102.61
35	109.96	962.11	85	267.04	5674.50	135	424.12	14313 88
36	113.10	1017.88	86	270.18	5808.80	136	427.26	14526.72
37	116.24	1075.21	87	273 32	5944.68	137	430.40	14741.14
38	119.38	1131.11	88	276.46	6082.12	138	433.54	14957.12
39	122.52	1194.59	89	279.60	6221.14	139	436.68	15174.68
40	125.66	1256.64	90	282.74	6361.73	140	439.82	15393.80
41	128.81	1320.25	91	285.88	6503.88	141	442.96	15614.50
42	131.95	1385.44	92	289.03	6647.61	142	446.11	15836.77
43	135.09	1452.20	93	292.17	6792.91	143	449 25	16060.61
44	138.23	1520.53	94	295.31	6939.78	144	452.39	16286.02
45	141.37	1590.43	95	298.45	7088.22	145	455.53	16513.00
46	144.51	1661.90	96	301.59	7238.23	146	458.67	16741.55
47	147.65	1734.94	97	304.73	7389.81	147	461.81	16971.67
48	150 80	1809.56	98	307.88	7542.96	148	464.96	17203.36
49	153.94	1885.74	99	311.02	7697.69	149	468.10	17436.62
50	157.08	1963.50	100	314.16	7853.98	150	471.24	17671.46

A "quadrant" is a quarter of a circle, as C.

A "tangent" is a straight line which touches the circle without intersecting it, as fg.

Circumference of a circle = Diameter × 3.1416.

Diameter of a circle = Circumference ÷ 3.1416.

Area of a circle = **Square of diameter × 0.7854; or = square of** circumference × 0.07958; or, = ½ diameter × ½ **circumference;** or, = square of radius × 3.1416.

Examples.—Diameter is 8 feet, what is circumference?

8 × 3.1416 = 25.133 feet.

Circumference is 28 feet, what is diameter?

28 ÷ 3.1416 = 8.91 feet.

Diameter is 8 feet, what is area?

8 × 8 × 0.7854 = 50.265 square feet.

Circumference is 28 feet, what is area?

28 × 28 × 0.07958 = 59.525 square feet.

½ diameter is 4 feet, ½ circumference 12.56, what is area?

4 × 12.56 = 50.24 square feet.

Radius = 4, then 4 × 4 × 3.1416 = 50.26 square feet.

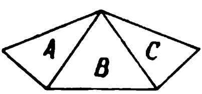


Fig. 35—To find the area of an irregular Polygon.

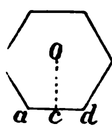


Fig. 36—To find the area of a regular Polygon

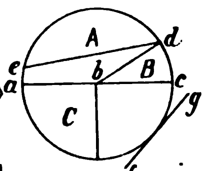


Fig. 37—Circle and Parts.

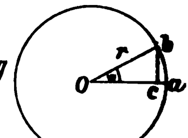


Fig. 38—Trigonometrical Functions.

To compute the area of a circle greater than any in the table. Divide the dimensions by 2, 3, 4, etc., if practicable, until it is reduced to a diameter to be found in the table. Take tabular area for this diameter, multiply it by the square of the divisor, and the product will be the area required.

TRIGONOMETRICAL FUNCTIONS.

If we have a circle of the radius *r* and we consider this line pivoted in *O*, the center of the circle, while the other end of the radius forms the circumference, and at any position of the traveling radius given by the angle *w*, we erect a vertical line upon *the starting line Oa through* the traveling point b of the radius.

we form a triangle *obc*, and the proportion of each two sides of it are the trigonometrical functions of angle *w*, called sine, cosine, tangent and cotangent, and written respectively "*sin, cos, tan* and *cot*."

$$\sin w = bc : r;\ \cos w = oc : r.$$
$$\tan w = bc : oc;\ \cot w = oc : bc.$$

Further $ab = arc$, $oba = sector$.

At 45° $\sin w = \cos w$, $\tan w = \cot w = 1$.

At 90° $\sin w = 1$, $\cos w = 0$.

Triangle *obc* is rightangled; therefore, $r^2 = (bc)^2 + (oc)^2$, and $1 = \sin^2 w + \cos^2 w$; $\tan w = \dfrac{\sin w}{\cos w}$; and $\cot w = \dfrac{\cos w}{\sin w}$.

If we have two angles w and w', then

$$\sin (w \pm w') = \sin w \times \cos w' \pm \cos w \times \sin w'.$$

SOLIDS OR BODIES.

A solid or body is that which has three dimensions: Length, breadth and thickness.

A "prism" is any solid whose two ends are parallel, similar and equal, and whose sides are parallelograms. Prisms are triangular, quadrangular, etc., according as the ends are triangles, quadrangles, etc. (Figs. 1-10.)

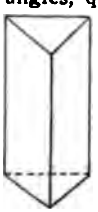


Fig. 1—Right Triangular Prism

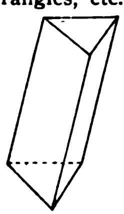


Fig. 2—Oblique Triangular Prism.

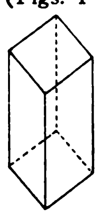


Fig. 3—Right Rectangular Prism.

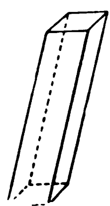


Fig. 4—Oblique Rectangular Prism.

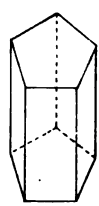


Fig. 5—Right Pentagonal Prism.

A "right" prism is one whose sides are perpendicular to its ends. (Figs. 1, 3, 5, 8, 10.)

An "oblique" prism is one whose sides are not perpendicular to its ends. (Figs. 2, 4, 6, 7, 9.)

When all the sides of the figures which form the ends are equal, and the angles included between those sides are also equal, the prism is said to be "regular" (Figs. 1, 2, 3, 4, 7, 8, 9, 10), *otherwise "irregular"* (*Figs.* 5, 6).

A "parallelopiped" is any solid contained within six sides, all of which are parallelograms, and those of each opposite pair, parallel to each other. Parallelopipeds are types of prisms (Figs. 7-10).

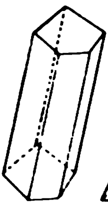
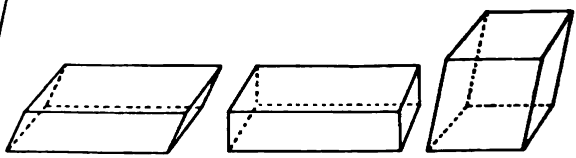


Fig. 6—Oblique Pentagonal Prism.



Figs. 7, 8 and 9—Parallelopipeds.

A "cube" is a right, rectangular prism, or a parallelopiped, having all its sides equal squares, and all its angles right angles (Fig. 10).

A "cylinder" is any solid whose ends are parallel, similar and equal curved figures, and whose sections, parallel to the ends, are everywhere similar and equal to the ends (Figs. 11-13).

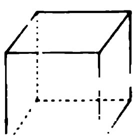


Fig. 10—Cube.

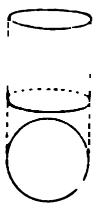


Fig. 11—Right Round Cylinder.

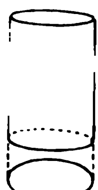


Fig. 12—Right Elliptical Cylinder.

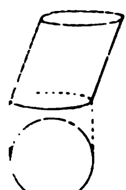


Fig. 13—Oblique Round Cylinder.

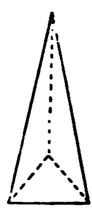


Fig. 14—Right Triangular Pyramid.

A "right" cylinder is one whose ends are perpendicular to its sides (Figs. 11, 12); when otherwise, it is "oblique" (Fig. 13). The most common form is the "right circular" cylinder, whose ends are circles (Fig. 11). Another form frequently used is the "right elliptical" cylinder, whose ends are ellipses (Fig. 12).

The altitude, or height, of a cylinder is the perpendicular distance between the ends.

A "pyramid" is any solid which has for its base a plane figure *of any number of sides*, and for its sides plane triangles meeting

in one point called "vertex" (Figs. 14-17). They are triangular, quadrangular, rectangular, etc., according as the basis is a triangle, quadrangle, rectangle, etc. When the base is a regular figure, the pyramid is said to be "regular" (Figs. 14 and 16),

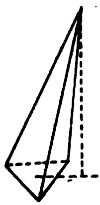


Fig. 15—Oblique Triangular Pyramid.

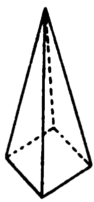


Fig. 16—Quadrangular Pyramid.

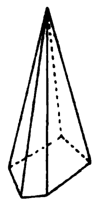


Fig. 17—Pentagonal Pyramid.

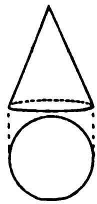


Fig. 18—Right Circular Cone.

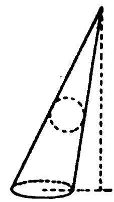


Fig. 19—Oblique Circular Cone.

otherwise "irregular" (Figs. 15 and 17.) The "altitude" or "height" of a pyramid is the perpendicular distance from vertex to base (Fig. 15).

A "cone" is a solid, of which the base is a curved figure, most commonly a circle, from which the surface tapers uniformly to a point called "vertex" (Figs. 18 and 19). The "altitude" or

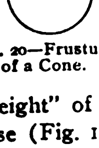


Fig. 20—Frustum of a Cone.

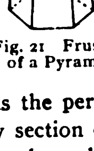


Fig. 21 Frustum of a Pyramid.

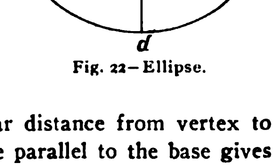


Fig. 22—Ellipse.

"height" of a cone is the perpendicular distance from vertex to base (Fig. 19). Any section of a cone parallel to the base gives a figure similar to the base, but smaller.

A section of a cone or cylinder when cut obliquely by a plane passing through the curved surface, or "mantle," without intersecting the base, is called an ellipse (Fig. 22); o, center; e and f, *foci; a c, long diameter* or axis; b d, short diameter or axis.

To find the area of an ellipse, multiply the product of its semi-axes by 3.1416; or, multiply the product of its axes by 0.7854.

Example.—The long axis is 12 feet, the short axis 8 feet, what is the area?

$6 \times 4 \times 3.1416 = 75.3984$ sq. ft.; or, $12 \times 8 \times 0.7854 = 75.3984$ sq. ft.

To find the circumference of an ellipse, approximately, D and d being the two axes, use the following formula:

$$\text{Circumference} = 3.1416\sqrt{\frac{D^2 + d^2}{2}}$$

The "frustum" of a cone or of a pyramid (also called a truncated cone or pyramid) is that part which remains after cutting off the upper part by a plane parallel to the base (Figs. 20 and 21).

A "sphere" is a solid in which every point of the surface is at an equal distance from a point called the center. It is generated by the revolution of a circle around its diameter. The surface of a sphere is $= 12.5664\ r^2 = 3.1416$ diameter$^2 = 0.3183$ circumference$^2 =$ diameter $\times$ circumference. The volume of a sphere is $4.1888\ r^3 = 0.5236$ diameter$^3 = 0.01689$ circumference$^3 = \frac{1}{6}$ diameter $\times$ area of surface.

MENSURATION OF SURFACES.

The unit of measure for surface is the "square foot."

To find the surface of a right prism, ascertain the areas of both ends and all sides, and add them together.

Areas of ends + areas of sides.

Example.—The side of the end of a square prism (a rectangular box or bin) is 6 feet, length 15 feet. What is the surface?

$6 \times 6 = 36 =$ area of one end, $\times 2 = 72 =$ area of both ends;
$6 \times 15 = 90 =$ area of one side, $\times 4 = 360 =$ area of four sides;

$72 + 360 = 432$ square feet.

To find the surface of a cube (a box of equal length, width and height), ascertain area of square forming its sides, and multiply by 6.

Area of end $\times$ 6.

Example.—Side of square is 4 feet. What is the surface of the cube?

$4 \times 4 = 16 =$ area of square; $16 \times 6 = 96$ square feet.

To find the surface of a cylinder, multiply the circumference of the end by the height, and add the areas of both ends.

Height $\times$ circumference $+ 2 \times$ area of end.

Example.—Diameter of round cylinder is 18 inches, the height 72 inches. Find the surface.

$18 \times 3.1416 = 56.54 =$ circumference; $56.54 \times 72 = 4070.88$;
Area of end is $18^2 \times 0.7854 = 254.472 \times 2 = 508.94 =$ areas of both ends.

$4070.88 + 508.94 = 4579.82$ square inches.

When internal surface only is to be computed, omit adding areas of top end, or both ends, as the case may be.

What is the height in an upright cylinder (round tank) is the length in a horizontal cylinder (storage vat).

To find the surface of a right pyramid, multiply the perimeter of the base by the slant height, measured along the slanting surface (that is, from the vertex to a point midway between two successive corners of the base), divide the product by two, and add to the quotient the area of the base.

(Perimeter of base $\times$ slant height) $\div 2 +$ area of base.

Example.—In a quadrangular pyramid a side is 8 feet, slant height 24 feet. What is the surface?

$8 \times 4 = 32 =$ perimeter of base; $(32 \times 24) \div 2 = 768 =$ area of sides.

$8 \times 8 = 64 =$ area of base; $768 + 64 = 832$ square feet.

To find the surface of a frustum of a pyramid, add the perimeters of both ends, multiply the sum by the slant height (that is, from a point midway between two successive corners of the base and a point midway between the two corresponding corners of the top), divide the product by 2, and add the areas of both ends.

[(Perimeter of base + perimeter of top) $\times$ slant height] $\div 2 +$ area of base + area of top.

Example.—In a frustum of a quadrangular pyramid the side of the base is 8 feet, of the top 6 feet, slant height 20 feet. What is the surface?

$8 \times 4 = 32$; $6 \times 4 = 24$; $32 + 24 = 56 =$ sum of perimeters;
$56 \times 20 = 1120 \div 2 = 560 =$ area of sides;
$8 \times 8 = 64$, area of base; $6 \times 6 = 36 =$ area of top;

$560 + 64 + 36 = 660$ square feet.

To find the surface of a right cone, multiply the circumference of the base by the slant height (that is, from the vertex to the circumference of the base), divide the product by 2, and add the area of the base.

(Circumference of base $\times$ slant height) $\div$ 2 + area of base.

Example.—The diameter of the base is 5 feet, the slant height 15 feet. What is the surface?

$5 \times 3.1416 = 15.708 =$ circumference of base; $15.708 \times 15 = 235.62 \div 2 = 117.81$;

$5^2 \times 0.7854 = 19.63 =$ area of base; $117.81 + 19.63 = 137.445$ square feet.

To find the surface of a frustum of a cone, add the circumferences of the two ends, multiply the sum by the slant height (that is, from a point in the circumference of the base to a corresponding point in the circumference of the top, the line so drawn to lie in a plane perpendicular to the base), divide the product by 2, and add the areas of the two ends.

[(Circumf. of base + circumf. of top) $\times$ slant height] $\div$ 2 + area of base + area of top.

Example.—The diameter of the base of a frustum of a cone is 10 feet, of the top 8 feet, slant height 12 feet. What is the surface?

$10 \times 3.1416 = 31.416 =$ circumference of base;

$8 \times 3.1416 = 25.131 =$ circumference of top;

$(31.416 + 25.132) \times 10 = 565.48 \div 2 = 282.74$;

$10^2 \times 0.7854 = 78.54 =$ area of base.

$8^2 \times 0.7854 = 50.265 =$ area of top.

$282.74 + 78.54 + 50.263 = 411.545$ square feet.

MENSURATION OF VOLUMES.

The unit of measure of capacity is the cubic foot.

To find the volume of a prism or parallelopiped, multiply the length by the breadth and the depth, or, the area of the base by the height (length).

Length $\times$ breadth $\times$ depth.

Example.—The three dimensions of a straight box are: Length 6 ft., breadth 2 ft., depth 4 ft. What is the volume?

$6 \times 2 \times 4 = 48$ cubic ft.

To find the volume of a cube. This applies to boxes, bins, etc., where length, breadth and height are equal.

The volume is the cube of the dimension; that is, multiply the *dimension twice by itself.*

[redacted]

Example.—The side of a cube is 24 inches. What is the volume? 24^3, or $24 \times 24 \times 24 = 13824$ cu. in., or $13824 \div 1728 = 8$ cu. ft.

To find the size of a box or bin to accommodate a required capacity.

First, reduce bushels to cubic feet; then, if a bin of equal length, width and height (that is, a cube) is wanted, extract the cube root of the number of cubic feet. The result is the inside dimension of the box.

Example.—Required capacity, 500 bu., dimensions of bin to be equal.

$$500 \text{ bu.} = 625 \text{ cu. ft}; \sqrt[3]{625} = 8.55 = 8 \text{ ft. } 6\tfrac{1}{2} \text{ in.}$$

If the bin is to be square, but not a cube, one of the dimensions must be given.

Example.—Required capacity, 500 bu.; depth, 6 ft. 3 in.

500 bu $= 625$ cu. ft.; $625 \div 6.25 = 100$; $\sqrt{100} = 10$ The length and width of the bin is 10 feet

Example.—Required capacity, 500 bu.; side, 10 ft.

500 bu. $= 625$ cu. ft.; $625 : 10 \times 10 = 6.25 = 6$ ft. 3 in.

If the bin is to be simply rectangular, but neither cubic nor square, two of the dimensions must be given.

Example.—Required capacity, 500 bu.; length, 12 ft.; depth, 6 ft.

500 bu. $= 625$ cu. ft.; $625 : 12 \times 6 = 8.68 = 8$ ft. $8\tfrac{1}{6}$ in.

To find the volume of a pyramid or cone, multiply the area of the base by one-third the perpendicular height.

Area of base $\times$ $\tfrac{1}{3}$ height.

Example.—The base of a rectangular pyramid is 3 feet by 4 feet, the height 6 feet. What is the volume?

$$3 \times 4 = 12;\ 12 \times \frac{6}{3} = 24, \text{ or } \frac{3 \times 4 \times 6}{3} = 24 \text{ cu. ft.}$$

Example.—The diameter of the base of a cone is 3 feet, height 12 feet. What is the volume?

$$\text{Area of base} = 7.068;\ \frac{7.068 \times 12}{3} = 28{,}272 \text{ cu. ft.}$$

To find the volume of a cylinder. This is the shape of most water tanks, mash tubs, etc.

Multiply the area of the base or end by the perpendicular height (or length, in case of an horizontal cylinder).

Area of base $\times$ height.

Example.—The diameter of a round cylinder is 3 feet, the height 12 feet. What is the volume?

Area of circle of 3 feet diameter = 7.068; 7.068 × 12 = 84.81 cubic feet.

To find the capacity of a cylinder in gallons, **multiply area of bottom in square inches by length in inches, and divide by 231.**

Example.—The diameters of an elliptical horizontal cylinder are 8 feet and 6 feet, the length 12 feet. What is the capacity?

$$\frac{96}{2} \times \frac{72}{2} = 48 \times 36 = 1728 \times 3.1416 = 5428.68 \text{ sq. in.}$$

$$5428.68 \times 144 = 781730 \text{ cu. in.}$$

$$781730 \div 231 = 3384.1 \text{ gal.}$$

CAPACITIES OF TANKS, TUBS, CISTERNS, CASKS, BINS, ETC.

The formulæ for rectangular prisms or parallelopipeds, cubes, pyramids, cones, cylinders, frustums of pyramids or cones, apply to all the boxes and vessels of regular geometrical shape used in the brewery. For those of irregular shape, approximate working formulæ are given.

For calculating capacities, take inside measurements.

Working formula for calculating capacity of a round tank:

(Diameter in feet) $^2 \times$ depth in feet × 5.878 = gallons; (diameter in feet) $^2 \times$ depth in feet × 0.1865 = barrels of 31½ gal.

Example.—Diameter of tank 6 feet, depth 10 ft.

36 × 10 × 5.878 = 2116.09 gal.

36 × 10 × 0.1865 = 67.14 barrels of 31½ gal.

To find the volume of a frustum of a pyramid or cone. This is the shape of most tubs, tanks and cisterns used in the chip cellar, fermenting cellar, etc.

1. $\frac{1}{3}$ perpendicular height $\times \left(\text{area of top} + \text{area of base} + \sqrt{\text{area of top} \times \text{area of base}}\right)$

2. For conical vessels only (approximate value):

$$\left(\frac{\text{Top diam.} + \text{bottom diam.}}{4}\right)^2 \times 3.14 \times \text{height.}$$

or,

$$\frac{\text{Top area} + \text{bottom area}}{2} \times \text{height}$$

[redacted]

Example.—The inside measurement of a fermenting tub are: Bottom diameter, 10 feet; top diameter, 9.5 feet; height, 7 feet. What is the capacity?

1. $\frac{1}{3} \times 7 \times (78.54 + 70.88 + \sqrt{78.54 \times 70.88} = 2.33 \times (149.42 + 74.42) = 521\ 547$ cu. ft.

2. $\left(\frac{9.5+10}{4}\right)^2 \times 3.14 \times 7 = 522.2$ cu. ft.

3. $\frac{70.88+78.54}{2} \times 7 = 522.97$ cu. ft.

Abridged working formula for calculating the capacity of round tanks in barrels of 31 gallons:

1. Reduce all measurements to inches; add diameters of bottom and top, and divide by 2, to obtain mean diameter. Square the mean diameter, multiply by 0.00011, and the product by the height.

Example.—Bottom diameter, 10 feet; top diameter, 9.5 feet; height, 7 feet.

$\frac{120+114}{2} = 117$; $117^2 = 13689 \times 0.00011 = 1.505 \times 84 = 126\ 42$ bbl.

2. Reduce all measurements to feet; find mean diameter as above. Square the mean diameter, multiply by 0.19, and the product by the height.

Example.—Same dimensions as above.

$\frac{10+9.5}{2} = 9.75$; $9\ 75^2 = 95.06 \times 0\ 19 = 18.06 \times 7 = 126.42$ bbl.

Manufacturers of tanks commonly calculate the capacities of tanks in the following way, the taper of the tanks being so slight —about ¾ inch to the rising foot—that the difference between the height of the vessel and the length of the side is ignored. Square the mean diameter of the tank in inches, multiply by the length of the stave in inches and the product by 0.0034; the result is the capacity in gallons. To obtain the length of the stave for this purpose, take off 2 inches from the actual extreme length, then take off 5 inches each for top and bottom for 2-inch lumber, and 6 inches each for 3-inch lumber.

(Mean diameter)^2 $\times$ stave $\times$ 0.0034 = gal.; stave = *actual length* — *2 in.* — 2×5 (or 2×6) in.

Example.—Mean diameter 12 ft., full length of stave 16 ft., 2-inch lumber. Find the capacity.

Length of stave 16 feet, less 2 inches, less 2×5 inches = 15 feet. Hence,

$144^2 \times 180 \times 0.0034 = 12960.432$ gal. $= 409.369$ beer barrels.

United States Measurement of cisterns and tanks. The above agrees substantially with the rule given to gaugers of the United States internal revenue service for use where the inside measurements of a cistern cannot be taken, as follows: "Take the outside circumference of the cistern, half way between the bottom and top; divide this by 3.1416 (or multiply by 7 and divide by 22), and you have the mean diameter on the outside; deduct from this twice the thickness of the staves, and you have the mean inside diameter. Multiply this sum by itself and by the height and the product by 0.0034. The product is the capacity of the cistern in gallons."

To find the capacity of a cask (approximately):

1. Reduce all measurements to inches. Square the mean diameter, multiply by length, and the product by 0.0034. The mean diameter is ½ the sum of the head and bung diameters, or, according to some authorities, the sum of ⅓ of the head diameter and ⅔ of the bung diameter. The result is the capacity in gallons.

$$(\text{Mean diameter})^2 \times \text{length} \times 0.0034.$$

Example.—Bung diameter 24 inches, head diameter 16 inches, length 36 inches.

$$\text{Mean diameter} = \frac{24+16}{2} = 20;\ 20 \times 20 \times 36 \times 0.0034 = 48.96 \text{ gal.}$$

2. Reduce all measurements to inches.

$\left(\dfrac{\text{Head diam.} + \text{bung diam.}}{4}\right)^2 \times 3.14 \times \text{length}.$ This gives the capacity in cubic inches.

Example: $\left(\dfrac{16+24}{4}\right)^2 \times 3.14 \times 36 = 11304$ cu. in.

United States Measurement of Casks. The regulations of the United States internal revenue office classify casks into three *varieties, the distinctions* being based on the curvature of the

staves at the quarter hoops, that is, midway between the bung and chimb. Following are the rules:

Variety 1 (least curvature).—Multiply difference between head diameter and bung diameter by 0.55, and add to product the head diameter.

Variety 2 (medium curvature).—Same, with decimal 0.63.

Variety 3 (greatest curvature).—Same, with decimal 0.70. This will give the mean diameter.

Then multiply the square of the mean diameter, in inches, by 0.0034 and by length in inches. The product is the capacity in gallons. Thus, for the dimensions 24, 16, 36, the capacities for the different varieties are (1) 50.94, (2) 54.18. (3) 57.1.

The familiar fact that casks seldom come up to their nominal capacity is due in part to a slight inward curvature of the heads, for which no allowance is anywhere provided.

"Ullage" is the amount of liquor in a cask when not full.

To find the ullage of a cask:

1. For a lying cask: Divide the number of wet or dry inches by the bung diameter in inches; if the quotient is less than 0.5, deduct from it one-fourth part of what it wants of 0.5; if it exceeds 0.5, add to it one-fourth of the excess over 0.5; multiply the remainder or sum by the contents of the whole cask in gallons. The product is the quantity of liquor in the cask in gallons, when the dividend is wet inches, or the empty space if dry inches.

2. For a standing cask: Divide the number of wet or dry inches by the length of the cask in inches. If the quotient exceeds 0.5, add to it one-tenth of the excess above 0.5; if less than 0.5, substract from it one-tenth of what it wants of 0.5; multiply the sum or the remainder by the contents of the whole cask in gallons. The product is the quantity of liquor in the cask, if the dividend is wet inches, or the empty space if dry inches.

To find the volume of a combined square box and pyramid—that is, the capacity of a *bin with hopper* and vessels of similar shape. This working formula is close enough for practical purposes, although not mathematically true, as it makes no allowance for the slight inaccuracy resulting from the fact that the inverted pyramid is not perfect, but rather a frustum, the *vertex being cut off* by the trap at the bottom.

CAPACITIES OF CYLINDRICAL VESSELS FROM 60 TO 240 INCHES DIAMETER PER FOOT OF HEIGHT.

Dia. in In.	Bbls.	Dia. in In.	Bbls.	Dia. in In.	Bbls.	Dia. in In.	Bbls.	Dia. in In.	Bbls.	Dia. in In.	Bbls.
60.	4.74	90.5	10.78	120.5	19.11	150.5	29.81	180.5	42.88	210.5	58.32
60.5	4.82	91.	10.90	121.	19.27	151.	30.01	181.	43.11	211.	58.59
61.	4.90	91.5	11.02	121.5	19.43	151.5	30.21	181.5	43.35	211.5	58.87
61.5	4.98	92.	11.14	122.	19.59	152.	30.41	182.	43.59	212.	59.15
62.	5.06	92.5	11.26	122.5	19.75	152.5	30.61	182.5	43.83	212.5	59.43
62.5	5.14	93.	11.38	123.	19.91	153.	30.81	183.	44.07	213.	59.71
63.	5.22	93.5	11.51	123.5	20.07	153.5	31.01	183.5	44.31	213.5	59.99
63.5	5.31	94.	11.63	124.	20.23	154.	31.21	184.	44.55	214.	60.27
64.	5.39	94.5	11.76	124.5	20.40	154.5	31.42	184.5	44.80	214.5	60.55
64.5	5.48	95.	11.88	125.	20.56	155.	31.62	185.	45.04	215.	60.83
65.	5.56	95.5	12.01	125.5	20.73	155.5	31.83	185.5	45.29	215.5	61.12
65.5	5.65	96.	12.13	126.	20.89	156.	32.03	186.	45.53	216.	61.40
66.	5.73	96.5	12.26	126.5	21.06	156.5	32.24	186.5	45.78	216.5	61.69
66.5	5.82	97.	12.38	127.	21.23	157.	32.44	187.	46.02	217.	61.97
67.	5.91	97.5	12.51	127.5	21.40	157.5	32.65	187.5	46.27	217.5	62.26
67.5	6.00	98.	12.64	128.	21.56	158.	32.85	188.	46.51	218.	62.54
68.	6.08	98.5	12.77	128.5	21.73	158.5	33.06	188.5	46.76	218.5	62.83
68.5	6.17	99.	12.90	129.	21.90	159.	33.27	189.	47.01	219.	63.12
69.	6.26	99.5	13.03	129.5	22.07	159.5	33.48	189.5	47.26	219.5	63.41
69.5	6.36	100.	13.16	130.	22.24	160.	33.69	190.	47.51	220.	63.69
70.	6.45	100.5	13.29	130.5.	22.41	160.5	33.90	190.5	47.76	220.5	63.98
70.5	6.54	101.	13.42	131.	22.58	161.	34.11	191.	48.01	221.	64.27
71.	6.63	101.5	13.56	131.5	22.76	161.5	34.33	191.5	48.26	221.5	64.57
71.5	6.73	102.	13.69	132.	22.93	162.	34.54	192.	48.51	222.	64.86
72.	6.82	102.5	13.82	132.5	23.11	162.5	34.76	192.5	48.76	222.5	65.15
72.5	6.92	103.	13.95	133.	23.28	163.	34.97	193.	49.02	223.	65.44
73.	7.01	103.5	14.09	133.5	23.46	163.5	35.19	193.5	49.28	223.5	65.74
73.5	7.11	104.	14.23	134.	23.63	164.	35.40	194.	49.53	224.	66.03
74.	7.20	104.5	14.37	134.5	23.81	164.5	35.62	194.5	49.79	224.5	66.33
74.5	7.30	105.	14.51	135.	23.98	165.	35.83	195.	50.04	225.	66.62
75.	7.40	105.5	14.65	135.5	24.16	165.5	36.05	195.5	50.30	225.5	66.92
75.5	7.50	106.	14.79	136.	24.34	166.	36.26	196.	50.55	226.	67.22
76.	7.60	106.5	14.93	136.5	24.52	166.5	36.46	196.5	50.81	226.5	67.52
76.5	7.70	107.	15.07	137.	24.70	167.	36.70	197.	51.07	227.	67.81
77.	7.80	107.5	15.21	137.5	24.88	167.5	36.92	197.5	51.33	227.5	68.10
77.5	7.91	108.	15.35	138.	25.06	168.	37.14	198.	51.59	228.	68.41
78.	8.01	108.5	15.49	138.5	25.24	168.5	37.37	198.5	51.85	228.5	68.71
78.5	8.11	109.	15.63	139.	25.42	169.	37.59	199.	52.11	229.	69.01
79.	8.21	109.5	15.78	139.5	25.61	169.5	37.81	199.5	52.38	229.5	69.32
79.5	8.32	110.	15.92	140.	25.79	170.	38.03	200.	52.64	230.	69.62
80.	8.42	110.5	16.07	140.5	25.98	170.5	38.26	200.5	52.91	230.5	69.92
80.5	8.53	111.	16.21	141.	26.16	171.	38.48	201.	53.17	231.	70.22
81.	8.63	111.5	16.36	141.5	26.35	171.5	38.71	201.5	53.44	231.5	70.53
81.5	8.74	112.	16.51	142.	26.53	172.	38.93	202.	53.70	232.	70.83
82.	8.85	112.5	16.67	142.5	26.72	172.5	39.16	202.5	53.97	232.5	71.14
82.5	8.96	113.	16.80	143.	26.91	173.	39.39	203.	54.23	233.	71.44
83.	9.07	113.5	16.95	143.5	27.10	173.5	39.62	203.5	54.50	233.5	71.75
83.5	9.18	114.	17.10	144.	27.29	174.	39.84	204.	54.77	234.	72.05
84.	9.29	114.5	17.25	144.5	27.48	174.5	40.07	204.5	55.04	234.5	72.37
84.5	9.40	115.	17.40	145.	27.67	175.	40.30	205.	55.31	235.	72.68
85.	9.51	115.5	17.56	145.5	27.86	175.5	40.53	205.5	55.58	235.5	72.99
85.5	9.62	116	17.71	146	28.05	176.	40.76	206.	55.85	236.	73.30
86.	9.73	116.5	17.86	146.5	28.25	176.5	41.00	206.5	56.12	236.5	73.61
86.5	9.85	117.	18.01	147.	28.44	177	41.23	207.	56.39	237.	73.92
87	9.96	117.5	18.17	147.5	28.64	177.5	41.47	207.5	56.67	237.5	74.23
87.5	10.08	118.	18.32	148.	28.83	178.	41.70	208	56.94	238.	74.54
88	10.19	118.5	18.48	148.5	29.03	178.5	41.94	208.5	57.21	238.5	74.86
88.5	10.31	119.	18.63	149.	29.22	179.	42.17	209.	57.48	239.	75.17
89.	10.42	119.5	18.79	149.5	29.43	179.5	42.41	209.5	57.75	239.5	75.49
89.5	10.54	120	18.95	150.	29.61	180.	42.74	210.	58.04	240.	75.80
90.	10.66										

Example.—In a bin with hopper the box is 5 ft. long, 5 ft. wide, 4 ft. 9 in. deep. The hopper (pyramid) is 2 ft. 6 in. deep. What is the capacity?

$$\text{Vol. of box} = 5 \times 5 \times 4.75 = \quad 118.75 \text{ cu. ft.}$$

$$\text{Vol. of pyramid} = \frac{5 \times 5 \times 2.50}{3} = 62.50 \text{ cu. ft.}$$

$$\text{Capacity of bin and hopper} = \quad 181.25 \text{ cu. ft.} = 146.16 \text{ bu.}$$

To find the volume of a combined round cylinder and cone that is, the capacity of a *steep tank with hopper* and similar vessels (approximate formula).

Add the volumes of the cylinder and of the cone.

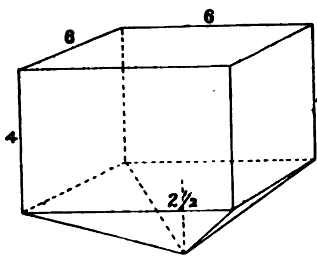


Fig. 23—Square Box with Pyramid. (Bin with Hopper.)

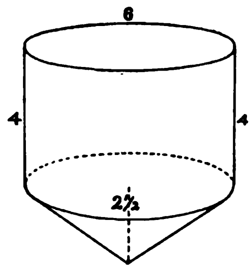


Fig. 24—Round Cylinder with Cone (Steep Tank with Hopper.)

Example.—In a steep tank, the tank proper (cylinder) measures 6 ft. diameter and 4 ft. depth, the hopper (inverted cone) 2 ft. depth. What is the capacity?

$$\text{Vol. of cylinder} = 6^2 \times 0.7854 = 28.2744 \times 4 = 113.0976 \text{ cu. ft.}$$

$$\text{Vol. of cone} \quad = 6^2 \times 0.7854 \times \tfrac{2}{3} = \quad 18.8496 \text{ cu. ft.}$$

$$\text{Capacity of steep tank and hopper} = \quad 131.9372 \text{ cu. ft.} = 106.4 \text{ bu.}$$

The brew-kettle is a vessel of wholly irregular shape, from a geometrical point of view. Its shape varies according to the requirements of the brewery, sometimes being broader and more shallow, and again deeper and more slender. The measurements given in the subjoined table are not intended to give the net contents of kettles, but the net brewing capacity, according to the methods customary among coppersmiths, which are almost *entirely empirical.* Thus, for a 100-barrel kettle, the bottom

diameter (B) is 8 feet 6 inches, the largest diameter (A) is 10 feet 6 inches. This gives a mean diameter of 9 feet 6 inches. The height of the shell (D) is 6 feet. Treating the vessel like a

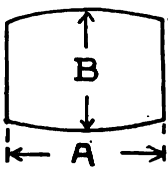


Fig. 25—Round Cask.

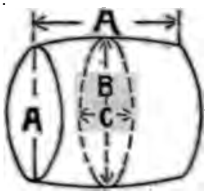


Fig. 26—Oval Cask.

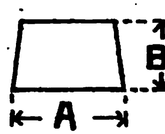


Fig. 27—Fermenter.

cylinder of the mean diameter of 9 feet 6 inches, the capacity is $(9' 6'')^2 \times 0.7854 \times 6 = 425.29$ cubic feet = 102.73 barrels of 31 gallons. The bottom below B is not figured at all, allowance being made for boiling down. Out of a copper of this size some brew-

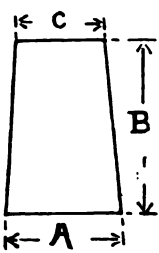


Fig 28—Stock Tub.

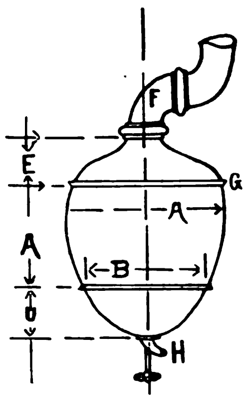


Fig. 29—Brew Kettle.

ers will turn out 115 barrels, some 110, some only 100. Architects and coppersmiths generally specify kettles large enough to allow for all methods of brewing.

It is possible to get approximate figures on the contents of a kettle by taking inside measurements at A and B and the height D and figuring as above; then adding thereto the contents of the

[redacted]

bottom calculated as a spherical segment, according to this formula: Square the radius (or ½ diameter) of circle B, multiply by 3; to the product add the square of the height (C) of the segment; multiply this sum by the height (C), and this last product by 0.5236. The formula accordingly for the whole kettle would be, for inside measurements:

$$\left(\frac{A+B}{2}\right)^2 \times 0.7854 \times D + \left[\left(\frac{B}{2}\right)^2 \times 3 + C^2\right] \times C \times 0.5236.$$

There is no way of calculating the capacity of a kettle, or of any other vessel, for that matter, with mathematical accuracy. The only strictly accurate test is to fill the vessel with water and measure its contents by a meter.

Customary dimensions and capacities of kettles, fermenting and stock tubs, round and oval casks:

ROUND CASKS.

Barrels.	A		B		C	
	Ft.	In.	Ft.	In.	Ft.	In.
30	6	0	6	6	6	0
40	6	2	7	0	6	2
50	7	0	7	10	7	0
60	7	6	8	2	7	6
70	7	10	8	6	7	10
80	8	2	9	0	8	2
90	8	6	9	3	8	6
100	9	0	9	7	9	0
110	9	4	9	11	9	4
120	9	6	10	3	9	6
130	9	6	10	7	9	6
150	9	8	11	0	10	8
170	10	0	11	6	10	0
200	11	0	13	0	11	0

OVAL CASKS

Barrels.	A		B		C		D	
	Ft.	In.	Ft	In.	Ft.	In.	Ft.	In.
50	6	8	8	0	6	8	6	8
100	8	2	9	2	8	2	8	2
103	7	6	10	6	9	3	9	3
125	8	8	9	8	8	8	8	8
150	9	2	10	4	9	3	9	8
170	9	8	10	7	9	8	9	8
175	10	6	11	0	9	1	9	1
186	10	6	12	0	10	0	10	0
200	10	2	11	4	10	2	10	2
250	11	0	13	4	11	4	11	4
312	10	6	14	0	12	0	12	0

The standard in common commercial use in the United States is the "avoirdupois" or "commercial" pound, which contains 7,000 grains and is practically identical with the British avoirdupois pound, which is the weight of 27.7015 cubic inches of distilled water in air at 39.2° F. with a barometer of 30 inches.

While the pound is the theoretical standard, the practical unit is the grain, which is equal in Troy, apothecaries' and avoirdupois or commercial weight.

MEASURES OF CAPACITY.

The measures of capacity in use in the United States have no exact equivalent in the measures of any other country. While many names are derived from the British, and, in some cases, are identical with the same, their values, as a rule, are quite different.

The units of capacity are the "gallon" for liquids and the "bushel" for dry measure.

The "standard liquid gallon" of the United States contains 231 cubic inches and is equal to 8.3389 pounds avoirdupois of pure water at 39.2° F. at a barometer of 30 inches. The "half peck" or "dry gallon" contains 268.8 cubic inches. The "imperial gallon" of Great Britain contains 277.274 cubic inches, being the volume occupied by 10 pounds of water weighed in air at 62° F. and 30 inches barometric pressure, and is equal to about 1.2 United States liquid gallons.

The "standard struck bushel" of the United States contains 2150.42 cubic inches (the old British Winchester struck bushel). or 1.2445 cubic feet, or 77.6274 pounds avoirdupois of pure water at 39.2° F. It is a cylindrical measure 18½ inches in diameter and 8 inches deep.

A "heaped bushel," which is like the foregoing, with a heaped cone not less than 6 inches high, is equal to 1¼ struck bushels.

The "imperial bushel" of Great Britain contains 2216.192 cubic inches, or 1.2837 cubic feet.

The United States "standard barrel" contains 31½ gallons.

The United States "beer barrel," according to the Internal Revenue laws of the United States, contains 31 gallons even. This should be used to measure water tanks, coppers, coolers, *etc., as well as chip casks,* fermenting tubs, etc.

METRIC SYSTEM.

The metric system is compulsory in France, Germany, Austria Hungary, Belgium, Spain, Portugal, Italy, Norway, Sweden. Switzerland, Servia, Roumania, Mexico, Brazil, Peru, Venezuela and the Argentine Republic. It is legalized but not compulsory in the United States (act of 1866), Great Britain, Denmark and Japan. In the United States, however, and in Great Britain, both custom and the greater convenience of computation—aside from notation—in the duodecimal over the decimal system have prevailed to maintain the old customary standards in common use. The Federal government has furnished exact metric standards to the several states. The metric system is used extensively in scientific work, as it requires no adaptation of different national standards, and thus facilitates the mutual exchange of scientific research in different countries

The metric unit is the meter, which was intended to be the ten-millionth part $(\frac{1}{10\,000,000})$ of the earth's quadrant, i. e., of that part of a meridian from either pole to the equator. After this length was obtained and a set of standards prepared and deposited in the archives of France, it was discovered that errors were made in the calculations. Nevertheless, the standards were left undisturbed.

The metric measures of surface and capacity are the squares and cubes of the meter, its decimal fractions or multiples.

The metric unit of weight is the gram, being the weight of a cubic centimeter of pure water at 39.2° F.

By convention among the leading nations of the world an international bureau of weights and measures has been created. with its seat near Paris, which has prepared two ingots of pure platinum-iridium. From one of these a number of standard kilograms have been made, and from the other a number of standard meter bars, both derived from the standards in the French archives. Certain of these copies were preserved as international standards, and others were distributed among the contributory governments. Those sent to the United States are in the possession of the Coast and Geodetic Survey. These copies of the international prototype meter and kilogram form the basis of official metrology in the United States.

Table of contributors to the International Bureau of Weights and Measures.

Countries.	Population.	Metric system.	Countries.	Population.	Metric system.
Argentine Confederation.	2,000,000	Obligatory	Servia	1,600,000	Obligatory.
Austria...........	20,136,283	Do.	Spain.............	21,456,468	Do.
Hungary	15,508,573	Do.	Switzerland.....	2,831,787	Do.
Belgium	5,635,452	Do.	Venezuela.	1,781,194	Do.
France...........	42,403,892	Do.	Great Britain and Ireland....	35,172,976	Permissive
Germany.........	45,194,172	Do.	Sweden...... ..	4,577,788	Do.
Italy.	28,209,620	Do.	Turkey..........	32,024,000	Do.
Norway.	1,900,000	Do.	United States...	50,000,000	Do.
Peru.............	2,699,945	Do.	Denmark........	1,980,675	Non-metric
Portugal.........	5,400,000	Do.	Japan............	37,011,964	Do.
Roumania.......	5,000,000	Do.	Russia...........	93,144,454	Do.

NOTE.—The amount of each country's contribution to the maintenance of the International Bureau has been determined by the population as given above and by the rating indicated by obligatory, permissive, and non-metric. The figures do not show the present population.

The relation of the South and Central American states to the metric system is shown in the following table:

Countries.	Population.	Remarks.
Argentine Rep....	3.000.000	Metric system obligatory: the law of 1887 prescribes penalties for the use of any other.
Bolivia....	2.500.000	Coin and custom-house weights metric: old Castilian weights and measures in common use.
Brazil	12.300,000	Metric system obligatory: old weights and measures used in the interior.
Chile............	2.500,000	Metric system legal since 1848.
Colombia	3.500,000	Metric system obligatory.
Costa Rica	200,000	Metric system obligatory since August, 1885, but legalized since 1858.
Ecuador..........	1.200,000	Metric system obligatory.
Guatemala	1,200,000	Metric system used in coinage and in land measure. Other weights and measures in common use.
Hayti.............	600,000	Metric coinage. Old French weights and measures in use.
Guiana:		
British	300,000	British system.
French	40,000	Metric system.
Dutch	70,000	Metric system.
Honduras.	350,000	Metric coinage, otherwise metric system not in use.
Mexico...........	10,500,000	Metric system legalized and obligatory in all government transactions. Old weights and measures in use.
Nicaragua........	300,000	
Paraguay...... ..	500,000	Metric system legalized, but old weights and measures in use.
Peru	3.000,000	Metric system obligatory.
Salvador	600,000	
San Domingo.....	200,000	Old French weights and measures in use.
Uruguay	600,000	Metric system legalized. Metric coinage.
Venezuela.......	2,200,000	Metric system obligatory.

As the equivalent of the meter in British and United States measure the United States Coast Survey adopts as the length of the meter at 62° F., the value of 39.370432 inches, = 3.2808666 feet, = 1.0936222 yards, as determined in 1866 at the British Ordnance Survey. The lawful equivalent established by Congress is 39.37 inches, = 3.28083 feet, = 1.093611 yards.

The legal weight of a gram in the United States is 15.432 grains.

In addition to the standards mentioned there is current a variety of customary measures of different denominations and irregular values, which are given under the several heads in the succeeding pages.

UNITED STATES CUSTOMARY MEASURES AND WEIGHTS.

MEASURES OF LENGTH (EXTENSION).

12 inches (in.) = 1 foot, ft.
3 feet = 1 yard, yd.
5½ yards or 16½ feet = 1 rod, rd. pole, or perch.
40 rods = 1 furlong, furl.
8 furlongs = 1 mile, mi.

mi.	furl.	rd.	yd.	ft.	in.
1 =	8 =	320 =	1760 =	5280 =	63360
	1 =	40 =	220 =	660 =	7920
		1 =	5½ =	16½ =	198
			1 =	3 =	36
				1 =	12

72 points = 1 inch.
6 points = 1 line.
12 lines = 1 inch.
4 inches = 1 hand.
3 barley-corns, or sizes = 1 in.
1,000 mils = 1 inch.
3 inches = 1 palm.
9 inches = 1 span.
8 spans, or 6 feet, or 2 yards = 1 fathom.
120 fathoms = 720 feet = 1 cable's length.
6080.27 feet = 1.1516 statute miles = 1 geographical or nautical mile (knot).
3 nautical mi. = 1 league.
60 nautical mi. (69.09 stat. mi.) = 1 degree latitude on a meridian, or longitude on the equator.
360 degrees = circumference of the earth at the equator.

Fathoms and cables are used for measuring rope; points and lines for pendulums.

SURVEYORS' LINEAR MEASURE.

7.92 inches = 1 link, l.
25 links = 1 rod, rd.
66 feet, or 4 rods = 1 Gunter's chain, ch.
80 chains = 1 mile, mi.

mi.	ch.	rd.	l.	in.
1 =	80 =	320 =	8000 =	63360
	1 =	4 =	100 =	792
		1 =	25 =	198
			1 =	7.92

[redacted]

INCHES IN DECIMALS OF A FOOT.

Ins.	Foot.	Ins.	Foot.	Ins.	Foot.	Ins.	Foot.	Ins.	Foot.	Ins.	Foot.
0	.0000	**2**	.1667	**4**	.3333	**6**	.5000	**8**	.6667	**10**	.8333
1-32	.0026		.1693		.3359		.5026		.6693		.8359
1-16	.0052		.1719		.3385		.5052		.6719		.8385
3-32	.0078		.1745		.3411		.5078		.6745		.8411
⅛	.0104	⅛	.1771	⅛	.3438	⅛	.5104	⅛	.6771	⅛	.8438
5-32	.0130		.1797		.3464		.5130		.6797		.8464
3-16	.0156		.1823		.3490		.5156		.6823		.8490
7-32	.0182		.1849		.3516		.5182		.6849		.8516
¼	.0208	¼	.1875	¼	.3542	¼	.5208	¼	.6875	¼	.8542
9-32	.0234		.1901		.3568		.5234		.6901		.8568
5-16	.0260		.1927		.3594		.5260		.6927		.8594
11-32	.0286		.1953		.3620		.5286		.6953		.8620
⅜	.0313	⅜	.1979	⅜	.3646	⅜	.5313	⅜	.6979	⅜	.8646
13-32	.0339		.2005		.3672		.5339		.7005		.8672
7-16	.0365		.2031		.3698		.5365		.7031		.8698
15-32	.0391		.2057		.3724		.5391		.7057		.8724
½	.0417	½	.2083	½	.3750	½	.5417	½	.7083	½	.8750
17-32	.0443		.2109		.3776		.5443		.7109		.8776
9-16	.0469		.2135		.3802		.5469		.7135		.8802
19-32	.0495		.2161		.3828		.5495		.7161		.8828
⅝	.0521	⅝	.2188	⅝	.3854	⅝	.5521	⅝	.7188	⅝	.8854
21-32	.0547		.2214		.3880		.5547		.7214		.8880
11-16	.0573		.2240		.3906		.5573		.7240		.8906
23-32	.0599		.2266		.3932		.5599		.7266		.8932
¾	.0625	¾	.2292	¾	.3958	¾	.5625	¾	.7292	¾	.8958
25-32	.0651		.2318		.3984		.5651		.7318		.8984
13-16	.0677		.2344		.4010		.5677		.7344		.9010
27-32	.0703		.2370		.4036		.5703		.7370		.9036
⅞	.0729	⅞	.2396	⅞	.4063	⅞	.5729	⅞	.7396	⅞	.9063
29-32	.0755		.2422		.4089		.5755		.7422		.9089
15-16	.0781		.2448		.4115		.5781		.7448		.9115
31-32	.0807		.2474		.4141		.5807		.7474		.9141
1	.0833	**3**	.2500	**5**	.4167	**7**	.5833	**9**	.7500	**11**	.9167
1-32	.0859		.2526		.4193		.5859		.7526		.9193
1-16	.0885		.2552		.4219		.5885		.7552		.9219
3-32	.0911		.2578		.4245		.5911		.7578		.9245
⅛	.0938	⅛	.2604	⅛	.4271	⅛	.5938	⅛	.7604	⅛	.9271
5-32	.0964		.2630		.4297		.5964		.7630		.9297
3-16	.0990		.2656		.4323		.5990		.7656		.9323
7-32	.1016		.2682		.4349		.6016		.7682		.9349
¼	.1042	¼	.2708	¼	.4375	¼	.6042	¼	.7708	¼	.9375
9-32	.1068		.2734		.4401		.6068		.7734		.9401
5-16	.1094		.2760		.4427		.6094		.7760		.9427
11-32	.1120		.2786		.4453		.6120		.7786		.9453
⅜	.1146	⅜	.2813	⅜	.4479	⅜	.6146	⅜	.7813	⅜	.9479
13-32	.1172		.2839		.4505		.6172		.7839		.9505
7-16	.1198		.2865		.4531		.6198		.7865		.9531
15-32	.1224		.2891		.4557		.6224		.7891		.9557
½	.1250	½	.2917	½	.4583	½	.6250	½	.7917	½	.9583
17-32	.1276		.2943		.4609		.6276		.7943		.9609
9-16	.1302		.2969		.4635		.6302		.7969		.9635
19-32	.1328		.2995		.4661		.6328		.7995		.9661
⅝	.1354	⅝	.3021	⅝	.4688	⅝	.6354	⅝	.8021	⅝	.9688
21-32	.1380		.3047		.4714		.6380		.8047		.9714
11-16	.1406		.3073		.4740		.6406		.8073		.9740
23-32	.1432		.3099		.4766		.6432		.8099		.9766
¾	.1458	¾	.3125	¾	.4792	¾	.6458	¾	.8125	¾	.9792
25-32	.1484		.3151		.4818		.6484		.8151		.9818
13-16	.1510		.3177		.4844		.6510		.8177		.9844
27-32	.1536		.3203		.4870		.6536		.8203		.9870
⅞	.1563	⅞	.3229	⅞	.4896	⅞	.6563	⅞	.8229	⅞	.9896
29-32	.1589		.3255		.4922		.6589		.8255		.9922
15-16	.1615		.3281		.4948		.6615		.8281		.9948
31-32	.1641		.3307		.4974		.6641		.8307		.9974

SURFACE OR SQUARE MEASURE.

144 squares inches (sq. in.) = 1 square foot, sq. ft.

9 square feet = 1 square yard, sq. yd. = 1,296 square inches.

40 square poles, or rods = 1 rood.

30¼ square yards, or 272¼ square feet = 1 square rod, or perch, *sq. rd., P.*

4 roods, or 10 sq. chains, 160 square rods, or 4840 sq. yards, or 43,560 sq. feet = 1 Acre, A.

640 acres = 1 square mile, sq. mi.

sq. mi.	A.	sq. rd.	sq yd.	sq. ft.	sq. in.
1 =	640 =	102,400 =	3,097,600 =	27,878,400 =	4,014,489,600

100 square feet = 1 square (Arch. and Build. measure).

CIRCULAR MEASURE.

60 seconds, ″ = 1 minute, ′
60 minutes, ′ = 1 degree, °
90 degrees, ° = 1 quadrant.
360 degrees, ° = circumference.

A circular inch is the area of a circle 1 inch in diameter = 0.7854 square inch; 1 square inch = 1.2732 circular inches.

LAND MEASURE (SURVEYORS' SQUARE MEASURE).

625 square links (sq. l.) = 1 pole, P.
16 poles = 1 square chain, sq. ch.
10 square chains = 1 acre, A.
640 acres = 1 square mile, sq. mi., or section.
160 acres = 1 quarter section.
36 square miles (6 mi. square) = 1 township, Tp.
1 township = 36 square miles = 23,040 acres.

MEASURES OF CAPACITY OR VOLUME.

CUBIC OR SOLID MEASURES.

1728 cubic in. = 1 cubic ft., cu. ft.
27 cubic ft. = 1 cubic yd., cu. yd.

cu. yd.	cu. ft.	cu. in.
1 =	27 =	46,656

LIQUID MEASURE.

4 gills (gi.) = 1 pint, pt.
2 pints = 1 quart, qt.
4 quarts = 1 gallon, gal.

gal.	qt.	pt.	gi.
1 =	4 =	8 =	32
	1 =	2 =	8
		1 =	4

Cu. ft. = 62.5 pounds (lb.) of water. Gallon (gal.) = 231 cu. in. = 8.34 lbs. water.

To reduce cubic inches to gallons, divide by 231; cu. in. ÷ 231 = gal.

To reduce gallons to cubic inches, multiply by 231; gal. × 231 = cu. in.

To reduce gallons to cubic feet, divide by 7.48. To reduce *cubic feet to gallons*, multiply by 7.48.

UNITED STATES GALLONS IN CUBIC FEET.

Gallons.	Cubic Ft.	Gallons.	Cubic Ft.	Gallons.	Cubic Ft.
1	.134	1,000	133.681	1,000,000	133,680.6
2	.267	2,000	267.361	2,000,000	267,361.1
3	.401	3,000	401.042	3,000,000	401,041.7
4	.535	4,000	534.722	4,000,000	534,722.2
5	.668	5,000	668.403	5,000,000	668,402.8
6	.802	6,000	802.083	6,000,000	802,083.3
7	.936	7,000	935.764	7,000,000	935,763.9
8	1.069	8,000	1,069.444	8,000,000	1,069,444.4
9	1.203	9,000	1,203.125	9,000,000	1,203,125.0
10	1.337	10,000	1,336.806	10,000,000	1,336,805.6

CUBIC FEET IN UNITED STATES GALLONS.

Cubic Ft.	Gallons.	Cubic Ft.	Gallons.	Cubic Ft.	Gallons.
0.1	0.75	50	374.0	8,000	59,844.2
0.2	1.50	60	448.8	9,000	67,324.7
0.3	2.24	70	523.6	10,000	74,805.2
0.4	2.99	80	598.4	20,000	149,610.4
0.5	3.74	90	673.2	30,000	224,415.6
0.6	4.49	100	748.0	40,000	299,220.8
0.7	5.24	200	1,496.1	50,000	374,025.9
0.8	5.98	300	2,244.2	60,000	448,831.1
0.9	6.73	400	2,992.2	70,000	523,636.3
1	7.48	500	3,740.3	80,000	598,441.5
2	14.96	600	4,488.3	90,000	673,246.7
3	22.44	700	5,236.4	100,000	748,051.9
4	29.92	800	5,984.4	200,000	1,496,103.8
5	37.40	900	6,732.5	300,000	2,244,155.7
6	44.88	1,000	7,480.5	400,000	2,992,207.6
7	52.36	2,000	14,961.0	500,000	3,740,259.5
8	59.84	3,000	22,441.6	600,000	4.488,311.4
9	67.32	4,000	29,922.1	700,000	5,236,363.3
10	74.80	5,000	37,402.6	800,000	5,984,415.2
20	119.6	6,000	44,883.1	900,000	6,732,467.1
30	224.4	7,000	52,363.6	1,000,000	7,480,519.0
40	299.2				

Beer barrel (bbl.) contains 31 gal. = 4.14 cu. ft. = 7,161 cu. i

To reduce cubic feet to beer barrels, divide by 4.14; cu. ft. ÷ 4.14 = beer bbl.

To reduce beer barrels to cubic feet, multiply by 4.14; bee bbl. × 4.14 = cu. ft.

Cubic foot = 0.24 beer bbl.; cubic inch = 0.00014 beer bbl.

Barrels and hogsheads are fixed measures only for the articl on which an Internal Revenue tax is levied, as beer, whisky, et *For ordinary* commercial purposes they are not fixed measures.

A hogshead of beer is two barrels, or not to exceed 63 gallo

[redacted]

The United States beer barrel, under the Internal Revenue law, as compared with other measures, is as follows:

Beer Barrels.	Bushels.	Cubic Feet.	Gallons.	Cubic Inches.
1.	3.33	4.144	31.	7161.
0.328	1.	1.244	9.309	2150.4
0.2413	0.804	1.	7.476	1728.
0.0323	0.1074	0.1337	1.	231.

FOR CISTERNS, TANKS, RESERVOIRS, ETC.

31½ gal. = 1 barrel, bbl.
63 gal. = 1 hogshead, hhd.

hhd.		bbl.		gal.		qt.		pt.
1	=	2	=	63	=	252	=	504
		1	=	31½	=	126	=	252

For hot water as for cold, barrel of 31 gal. = 7161 cu. in. = 4.14 cu. ft.; 1 cu. ft. = 0.24 bbl. The contraction of volume of water or wort in cooling from boiling to greatest density is 4.5 per cent. To find the volume that boiling hot water or wort will occupy when so cooled, multiply the volume of the hot fluid by 95½ and divide by 100, or multiply by 0.955.

United States standard barrel contains 31½ gal. = 4.21 cu. ft. (in practice often figured roughly at 4.¼ cu. ft.).

To reduce cubic feet to United States standard barrels, divide by 4.21 (roughly 4.25); cu. ft. ÷ 4.21 = standard bbl.

To reduce United States standard barrels to cubic feet; multiply by 4.21 (roughly 4.25); standard bbl. × 4.21 = cu. ft.

APOTHECARIES' FLUID MEASURE.

60 minims, or drops = 1 fluid drachm.
8 fluid drachms = 1 fluid ounce.
16 fluid ounces = 1 pint.
8 pints = 1 gallon.

To reduce United States liquid measures to British, of the same denomination, divide by 1.2; or to reduce British to United States, multiply by 1.2. The British Imperial gallon contains 277.274 cubic inches, or is equal to 1.2 United States gallon.

MISCELLANEOUS FLUID MEASURES.

Tierce = 42 gals.
Butt of sherry = 108 gals.
Pipe of port = 115 gals.
Pipe of Teneriffe = 100 gals.
Butt of Malaga = 105 gals.
Puncheon of Scotch whisky = 110-130 *gals.*
Puncheon of brandy = 110-120 gals.
Puncheon of rum = 100-110 gals.
Hogshead of brandy = 55-60 gals.
Hogshead of claret = 46 gals.

A hogshead is ½, a quarter ¼, an octave ⅛ of a pipe, butt or puncheon.

DRY MEASURE.

United States bushel (bu.) = 2150.42 cu. in = 1.2445 cu. ft. = 77.6274 pounds avoirdupois of pure water at 39.2° F.; 1 cu. ft. = 0.80356 struck bushel.

To reduce cubic feet to bushels, divide by 1.24; cu. ft. ÷ 1.24 = bu. For practical purposes subtract from cubic feet one-fifth of their number to obtain bushels; cu. ft. — ⅕ cu. ft. = bu.

To reduce bushels to cubic feet, multiply by 1.24; bu. × 1.24 = cu. ft. For practical purposes add to the number of bushels one-fourth of their number to obtain cubic feet; bu. + ¼ bu. = cu. ft.

The half-peck or dry gallon contains 268.8 cubic inches.

2 pints (pt.) = 1 quart, qt.
8 quarts = 1 peck, pk.
4 pecks = 1 bushel, bu.

bu.	pk.	qt.	pt.	cu. in.
1 =	4 =	32 =	64 =	2150.42
	1 =	8 =	16 =	537.6
		1 =	2 =	67.2

A heaped bushel contains 2747.715 cubic inches.

The dry flour barrel = 3.75 cu. ft. = 3 struck bushels. The dry barrel is not a fixed measure, however, and barrels vary considerably in size.

The imperial bushel of Great Britain contains 2216.192 cu. in., or 1.2837 cu. ft.

To reduce United States dry measures to British, of the same denomination, divide by 1.032; to reduce British into United States, multiply by 1.032.

COMPARATIVE TABLE OF MEASURES OF CAPACITY.

	Cu. In. in One Gallon.	Cu. In. in One Quart.	Cu. In. in One Pint.	Cu. In. in One Gill.
Liquid measure	231	57¾	28⅞	7 7/32
Dry measure..	268⅘	67⅕	33⅗	8⅖

SHIPPING MEASURE.

100 cu. ft. = 1 register ton.

U. S. shipping ton = 32.143 U. S. bu. = 31.16 Imper. bu. = 40 *cu. ft.*

British shipping ton = 33.75 U. S. bu. = 32.719 Imper. bu. = 42 cu. ft.

WOOD MEASURE.

In measuring wood, a pile of wood cut 4 ft. long, piled 4 ft. high and 8 feet on the ground, is called a cord.

16 cubic feet = 1 cord foot, cd. ft.
8 cord feet, or 128 cubic feet = 1 cord, cd.

In board measure, boards are assumed to be one inch in thickness. To obtain the number of feet board measure (B. M.) of a board, or piece of square timber, multiply length in feet, breadth in feet and thickness in inches.

1 board ft. = 1 ft. long, 1 ft. wide, 1 inch thick.
12 board ft. = 1 cu. ft.
Board feet ÷ 12 = cu. ft.
Cu. ft. × 12 = board ft.

To find surface in square feet, all dimensions being in feet, multiply length by breadth. When either dimension is in inches, multiply as above, and divide the product by 12. When all dimenions are in inches, multiply as above and divide by 144.

To find volume of square cut timber, all dimensions being in feet, multiply length, breadth and depth, the result will be the volume in cubic feet. When one dimension is in inches, multiply as above, and divide by 12. When two dimensions are in inches, multiply as above and divide by 144. When all three dimensions are in inches, multiply as above and divide by 1728.

To find the volume of round timber.—When dimensions are in feet, multiply the mean girth by the diameter, divide by 4, and multiply by the length. The result gives the cubic feet. When the length is in feet, girth and diameter in inches, proceed as above, and divide the product by 144. When all dimensions are in inches, proceed as in the first case, and divide the product by 1728.

STONE AND MASONRY MEASURE.

Masonry and stone are measured by the cubic foot and by the perch, or, superficially, by the square foot or square yard. A perch is 16½ ft. long, 1½ ft. wide, 1 ft. high, and contains 24.75 cu. ft. In measuring a stone wall a perch is often figured at 22 cu. ft. of stone, 2.75 being allowed for mortar, and in some of *the New England* states a perch is called 16½ cu. ft. Excava-

tions are measured by the cubic yard; 1 cu. yd. is called a load. Brickwork is figured by the thousand of bricks, or in cubic feet.

MEASURES OF WEIGHT.

AVOIRDUPOIS OR COMMERCIAL WEIGHT.

This is the measure used in all ordinary business transactions, and is understood to be taken for the standard, unless otherwise specified.

16 drams = 1 ounce (oz.) = 437.5 grains, gr.
16 ounces = 1 pound (lb.) = 7000 grains.
28 pounds = 1 quarter, qr.
4 quarters = 1 hundredweight, cwt. = 112 lbs.
20 hundredweights = 1 ton of 2240 lbs., or long ton.
2000 pounds = 1 net, or short ton.
2204.6 pounds = 1 metric ton.
1 stone = 14 pounds; 1 quintal = 100 pounds.

The long, or gross ton, hundredweight and quarter were formerly in common use, but now are used almost exclusively by the United States custom houses, and in freighting coal and selling it by wholesale.

TROY WEIGHT.

24 grains (gr.) = 1 pennyweight, pwt., or dwt.
20 pennyweights = 1 ounce, oz.
12 ounces = 1 pound, lb.

lb.		oz.		pwt.		gr.
1	=	12	=	240	=	5760
		1	=	20	=	480
				1	=	24

Troy weight is used for gold and silver.

A "carat" is used by jewelers in weighing precious stones. In the United States it is = 3.2 grains = 0.205 gram. In London it is = 3.17 grains, in Paris = 3.18 grains, which is subdivided into 4 "jewelers' grains."

The term "carat" is also used to designate the fineness of gold, pure gold being 24 carat, and alloyed gold, according to the ratio of gold and alloy, 22, 20, 16, etc., carat.

APOTHECARIES' WEIGHT.

20 grains (gr.) = 1 scruple, sc. or ℈.
3 scruples = 1 dram, dr. or ʒ = 60 grains.
8 drams = 1 ounce, oz. or ℥ = 480 grains.
12 ounces = 1 pound, lb. or ℔ = 5760 grains.
℔ = ℥ 12 = ʒ 96 = ℈ 288 = gr. 5760.

The pound, ounce and grain of apothecaries' weight are the *same as those of Troy* weight, the ounce being differently divided.

[redacted]

MISCELLANEOUS WEIGHTS.

The following weights are in general use, either by virtue of custom or of law:

32 lbs. of oats = 1 bu.	100 lbs. of meal or flour = 1 sack.
48 lbs. of barley = 1 bu.	100 lbs. of grain or flour = 1 cental.
56 lbs. of rye = 1 bu.	100 lbs. of dry fish = 1 quintal.
56 lbs. of ind. corn = 1 bu.	100 lbs. of nails = 1 cask.
50 lbs. of ind. meal = 1 bu.	196 lbs. of flour = 1 barrel.
60 lbs. of wheat = 1 bu.	200 lbs. of beef or pork = 1 barrel.

COMPARISON OF DIFFERENT WEIGHTS.

In computing weights given in different measures (Avoirdupois, Troy and Apothecaries') in any of the other measures, reduce all to *grains*, the grain being the same in the three standards.

	Troy.	Avoirdupois.	Apothecaries'.
1 pound	= 5760 grains	= 7000 grains	= 5760 grains.
1 ounce	= 480 grains	= 437.5 grains	= 480 grains.
	175 pounds	= 144 pounds	= 175 pounds.

COAL MEASURE.

Anthracite cu. ft. = 1.75 broken.
Anthracite 50-55 lbs. per cu. ft.
Anthracite 41-45 cu. ft. = 1 ton broken.
Bituminous 70-78 lbs. = heaped bushel.
Bituminous 40-50 lbs. = cu. ft.
Charcoal (hardwood) 18.5 lbs. = cu. ft.
Charcoal (pinewood) 18 lbs. = cu. ft.

WEIGHT OF HORSES.

Weight of horses ranges from 800 to 1,200 lbs.

THE METRIC SYSTEM.

The metric system employs the decimal notation, being based upon decimal calculation entirely. The primary unit is the meter for the measure of length. Derivative units are: "Are" for surface, "liter" for capacity, "gram" for weight. Denominations of decimal fractional parts, or decimal multiples of the units are formed by prefixing Greek numerals for the higher denominations, as dekameter = 10 meters, hektometer = 100 meters, kilometer = 1,000 meters, myriameter = 10,000 meters; or Latin numerals for the lower denominations, as decimeter = 0.1 meter, centimeter = 0.01 meter, millimeter = 0.001 meter.

[redacted]

ELEMENTS OF THE METRIC SYSTEM.

Length.	Surface.	Capacity.	Weight.	Notation.
			Metric Ton	1000000.
			Quintal	100000.
Myriameter			Myriagram	10000.
Kilometer		Kiloliter	Kilogram	1000.
Hektometer	Hektare	Hektoliter	Hectogram	100.
Dekameter	Dekare	Dekaliter	Dekagram	10.
Meter.	Are.	Liter.	Gram.	1.
Decimeter		Deciliter	Decigram	0.1
Centimeter	Centiare	Centiliter	Centigram	0.01
Millimeter		Milliliter	Milligram	0.001
Micromillimeter				0.000001

MEASURES OF LENGTH.

1 Millimeter, mm. = 1,000 micromillimeters.
1 Centimeter, cm. = 10 millimeters.
1 Decimeter, dm. = 10 centimeters.
1 Meter, m. = 10 decimeters.
1 Dekameter, Dm. = 10 meters.
1 Hektometer, hm. = 10 dekameters.
1 Kilometer, km. = 10 hektometers.
1 Myriameter, Mm. = 10 kilometers.

1356 mm. may be written 135.6 cm. or 13.56 dm. or 1.356 m. or 0.1356 Dm.

The micromillimeter is used in microscopical measures.

The millimeter is used in mechanical and scientific measures.

The meter is used in measuring short distances.

The kilometer is used in measuring long distances (roads, etc.).

MEASURES OF SURFACE.

The units of square measure are squares, the sides of which are equal to a unit of long measure.

1 sq. mm.
1 sq. cm. = 100 sq. millimeters.
1 sq. dm. = 100 sq. centimeters.
1 sq. m., or 1 centare, ca. = 100 sq. decimeters.
1 sq. Dm., or are. = 100 sq. meters.
1 sq. hm., or 1 hektare, ha. = 100 sq. dekameters.
1 sq. km. = 100 sq. hektometers.

MEASURES OF VOLUME.

The units are cubes, the edges of which are equal to a unit of *long measure.*

[redacted]

1 cu. centimeter, c. cm. or c.c. = 1000 cu. millimeters, c. mm.
1 cu. decimeter, c. dm. = 1000 cu. centimeters.
1 cu. meter, c. m. = 1000 cu. decimeters.
1 cubic decimeter liquid or dry measure = 1 liter, l.

WOOD MEASURE.

1 cubic meter or stere = 10 decisteres = 1000 cu. decimeters = 0.2759 cord, or 35.3165 cu. feet.
1 dekastere = 10 steres = 2.759 cords.

MEASURES OF CAPACITY.

The unit of capacity is the liter, for liquid and dry measure, being equal to a cubic decimeter of water, which at maximum density will counterpoise the standard kilogram in vacuum.

The hektoliter is the unit in measuring large quantities of grain, fruits, liquids (beer), etc.

1 Centiliter, cl. = 10 milliliters.
1 Deciliter, dl. = 10 centiliters.
1 Liter, l. = 10 deciliters.
1 Dekaliter, Dl. = 10 liters.
1 Hektoliter, hl. = 100 liters.
1 Kiloliter, kl., or stere = 1000 liters.
1 Myrialiter, Ml. = 10000 liters.

MEASURES OF WEIGHT.

1 Milligram, mg.
1 Centigram, cg. = 10 milligrams.
1 Decigram, dg. = 10 centigrams.
1 Gram, g. = 10 decigrams.
1 Dekagram, Dg. = 10 grams.
1 Hektogram, hg. = 10 dekagrams.
1 Kilogram, kg. = 10 hektograms.
1 Myriagram, Mg. = 10 kilograms.
1 Quintal or meter hundredweight, Q. = 10 myriagrams or 100 kilos.
1 Tonneau or metric ton or millier = 10 Quintals or 1000 kilos.

The kilo is the common commercial weight in countries using the metric system, and is the weight of a liter (cu. dm.) of water at greatest density.

The ton is used for weighing very heavy articles and is the weight of a cubic meter of water.

CONVERTING METRIC TO COMMON MEASURE, AND VICE VERSA.

To change the metric to the common system, reduce the metric *number to the denomination* of the principal unit of the table;

then multiply by the equivalent in the common system and reduce the product to the required denomination.

Example.—4.6 km., how many feet?

4.6 km. × 1000 = 4600 m.

39.37 in. × 4600 = 181102 inches = 1508.5 feet.

To change the common to the metric system, reduce the given quantity to the denomination in which the equivalent of the principal unit of the metric table is expressed; then divide by this equivalent and reduce the quotient to the required denomination.

Example.—In 12 lbs. 6 oz. Troy, how many kilograms?

12 lbs. 6 oz. = 12.5 lbs.

12.5 lbs. × 5760 grains = 72000 grains.

72000 grains ÷ 15.432 grains Tr. = 4665.63 grams.

4665.63 grams ÷ 1000 = 4.66563 kg.

APPROXIMATE EQUIVALENTS OF COMMON AND METRIC MEASURES (SUFFICIENT FOR ORDINARY PRACTICAL PURPOSES).

LONG MEASURE.

1 kilometer = 0.625 mile.
1 mile = 1.6 kilometers.
1 pole or perch = 5 meters.
1 chain = 20 meters.
1 furlong = 200 meters.
5 furlongs = 1 kilometer.
1 foot = 3 decimeters = 30 centimeters.
1 meter = 3.280833 feet = 3 feet 3⅜ inches.
11 meters = 12 yards.
1 decimeter = 4 inches.
1 centimeter = full ⅜ inch.
1 millimeter = $\frac{1}{25}$ inch.

To convert meters into inches, multiply by 40.

To convert inches into meters, divide by 40.

To convert meters (or fractions) into yards, add $\frac{1}{11}$ part or 0.0909 of the number of meters.

SQUARE MEASURE.

1 square inch = 6.5 square centimeters.
1 square meter = 10.75 square feet.
1 acre = 1.16 per cent over 4,000 square meters.
1 square mile = 259 hectares.

MEASURES OF VOLUME.

1 gallon = 3.85 liters.
1 liter = 0.26 gallons = 1.06 liquid quart = 2.11 pints.
1 cubic foot = 28.3 liters.
1 cubic meter = 1.33 cubic yards.
1 cubic yard = 0.75 cubic meter.

1 kiloliter of water = 2204 lbs.

1 hectoliter = 2.8 bushels = 26.4 gallons = 1.17 beer barrel = 1.19 standard barrel.

MEASURES OF WEIGHT.

1 ton = 1.016 kilograms.
1 gram = 15.5 grains.
1 kilogram = 2.2 lb. avoirdupois.

1,000 kilograms (1 metric ton) = 1 English ton, less 1.5 per cent.

ALPHABETICAL COMPARATIVE TABLES OF COMMON AND METRIC MEASURES.

LONG MEASURE.

Measures.	Feet.	Inches.	Miles.	Meters.	Kilometers.
Centimeter........	0.03280	0.3937	....	0.01	....
Chain..............	....	....	....	20.117	0.0201
Decimeter.........	0.32808	3.937	....	0.1	....
Dekameter.........	32.80833	393.7	....	10.	....
Fathom...........	6.	72.	....	1.8288	....
Foot..............	1.	12.	....	0.3048	....
Furlong...........	660.	7920.	0.125	201.16	0.20116
Hand..............	0.3333	4.	....	0.1016	....
Hektometer.......	328.0833	....	0.0621	100.	0.1
Inch..............	0.0833	1.	....	0.0254	....
Kilometer........	3280.833	....	0.6213	1000.	1.
League...........	18241.	....	3.45	4827.9	4.8279
Line..............	....	0.0833	....	0.002116	....
Link..............	0.666	8.	....	0.2032	....
Meter.............	3.28083	39.37	0.00062	1.	0.01
Mile, Statute....	5280.	63360.	1.	1609.	1.6093
Millimeter........	0.00328	0.03937	....	0.001	....
Myriameter.......	....	....	6.2138	10000.	10.
Perch, Pole, Rod..	16.5	198.	....	5.0290	0.005
Span..............	0.75	9.	....	0.2286	....
Yard..............	3.	36.	0.0006	0.9144	0.0009

SQUARE MEASURES.

Measures.	Sq. In.	Sq. Feet.	Sq. Yds.	Acres.	Sq. Meters.
Sq. Centimeter.	0.155	0.00107641	....	....	0.0001
Sq. Dekam't'r. Arc	....	1.0764101	119.601	0.0247	100.
Sq. Decimeter...	15.5	0.10764101	....	....	0.01
Sq. Foot..........	144.	1.	0.111	....	0.0929
Sq. Kilometer....	....	0.3861 sq. mi.	....	247.	1000000.
Sq. M't'r (Centiare)	1550.	10.764101	1.19601	....	1.
Sq. Mile..........	....	....	3097600	640.	....
Sq. Millimeter....	0.00155	0.00001076	....	....	0 000001
Sq. Rod..........	....	272.225	30.25	0.00625	25.293
Sq. Yard..........	1296.	9.	1.	0 0002	0.8361
Acre..............	....	43560.	4840.	1.	4046.86
Dekare...........	....	10764 1	1196.01	0 2471	1000.
Hektare..........	....	107641.	11960.11	2.4711	10000.
Square Inch......	*1.*	0.007	....	....	0.00065

CUBIC MEASURES (MEASURES OF VOLUME).

Measures.	Cubic Feet, Inches, or Yards.	Metric.
Cubic centimeter	0.061025 cu. in.	1. c. cm.
Cubic decimeter	61.0254 cu. in. or 0.0353 cu. ft.	1. c. dm.
Cubic foot	1728. cu. in.	28.3161 c. dm.
Cubic inch	1. cu. in.	16.3866 c. cm.
Cubic meter, or Stere	35.3156 cu. ft. or 1.3080 cu. yd.	1. c. m.
Cubic millimeter	0.00610 cu. in.	1. c. mm.
Cubic yard	27. cu. ft.	0.76453 c. m.

EQUIVALENTS OF LIQUID MEASURES IN COMMON AND METRIC MEASURES, AND CUBIC FEET OR INCHES.

Measures.	U. S. Measure.		Cu. In. or Ft.		British Measures.		Liters.
Barrel, Beer, U. S.	31.	gal	4.144	cu. ft.	25.8190	gal.	117.3443
Barrel Standard, U. S.	31.5	"	4.211	" "	26.243	"	119.2369
Barrel, Beer, British	43.21152	"	5.776	" "	36.	"	163.5684
Centiliter	0.01057	qt.	0.610254	" in.	0.0880	qt.	0.01
Dekaliter	10.567 or 2.6417	" gal.	0.353156	" ft.	2.2008	gal.	10.
Deciliter	0.10567	qt.	6.10254	" in.	0.8803	qt.	0.1
Firkin, British	10.828	gal.	1.444	" ft.	9.	gal.	40.89
Fluid Drachm, U. S.	0.0039	qt.	0.2256	" in.	0.00325	qt.	0.00369
Fluid Ounce, U. S.	0.03125	"	1.8047	" "	0.02603	"	0.02957
Gallon, Standard, U. S.	1.	gal.	231.	" "	0.833	gal	3.7853
Gallon, Imperial British *)	1.20032	"	277.274 / 277.463 (new)	" " / " "	1.	"	4.5435 / 4.5465 (new)
Gill, U. S.	0.125	qt.	7.21875	cu. in.	0.1041	qt.	0.1183
Gill, British	0.1501	"	8.6648	" "	0.125	"	0.142
Hektoliter	26.4179	gal.	3.53156	" ft.	22.008	gal.	100
Hogshead, U. S.	63.	"	8.4215	" "	52.486	"	238.473
Hogshead, British	64.8173	gal.	8.6647	" "	54.	"	245.343
Kilderkin, British	21.6057	"	2.8882	" "	18.	"	81.78
Kiloliter, =cubic meter	264.179	"	35.3156	" "	220.09	"	1000.
Liter	1.0567	qt	61.0254	" in.	0.8803	qt.	1.
Milliliter, =cubic centimeter	0.001056	"	0.0610254	" "	0.00088	"	0.001
Pint, U. S.	0.5	"	28.875	" "	0.4163	"	0.4731
Pint, British	0.6002	"	34.6592	" "	0.5	"	0.5679
Pipe, U. S. (Butt)	126.	gal.	16.84375	" ft.	104.972	gal.	476.947
Pipe, British (Butt)	129.6346	"	17.3294	" "	108.	"	490.7
Puncheon, U. S.	84.	"	11.229	" "	69.98	"	317.963
Puncheon, British	129.635	"	17.3294	" "	108.	"	490.7
Quart, U. S.	1.	qt	57.750	" in.	0.8331	"	0.9463
Quart, British	1.20032	"	69.3185	" "	1.	"	1.1358
Tierce, U. S.	42.	gal.	5.61145	" ft.	34.99	"	158.98
Tierce, British	43.2115	"	5.7765	" "	36.	"	163.566
Tun, U. S.	252.	"	33.68873	" "	209.904	"	953.896
Tun, British	259.270	"	34.6588	" "	216.	"	981.414

*(Imperial Gallon of 1824. Since 1890, 1 Imp. Gallon = 277.463 cubic inches = *4.5465718 Liter; 1 liter = 0.2197* Imp. gal.

EQUIVALENTS OF ONE CUBIC FOOT IN COMMON AND METRIC MEASURES.

Measures.	1 Cubic Foot =
Barrel, U. S., Standard, 31.5 gals	0.23748
Barrel, U. S., Beer, 31 gals	0.24181
Bushel, struck, U. S., 2150.42 cu. in	0.803564
Bushel, British, 2218.19 cu. in	0.779013
Gallon, U. S., liquid, 231 cu. in	7.48052
Gallon, U. S., dry	6.42851
Gallon, British, 277.274 cu. in	6.23210
Inches, cubic	1728.
Liter	28.3161
Peck, U. S.	3.21426
Peck, British	3.11605
Pints, U. S., liquid	59.84416
Pints, U. S., dry	51.42809
Pints, British	49.85684
Quarts, U. S., liquid	29.92208
Quarts, U. S., dry	25.71405
Quarts, British	24.92842
Yard, cubic	0.037037

EQUIVALENTS OF DRY MEASURES IN COMMON AND METRIC MEASURES AND CUBIC FEET OR INCHES.

Measures.	U. S. Measure.	Cubic Inches or Feet.	British Measure.	Liters.
Bushel, U. S., Win.	1. bu.	2150.420 cu. in. 1.2445 " ft.	0.9694 bu.	35.2368
Bshl, Brit., Imp...	1.031516 "	2218.192 " in. 1.2837 " ft.	1. "	36.3480
Centiliter	0.018162 dry pint	0.610254 " in.	0.01761 dry pint	0.011
Coomb, British	4.126064 bu.	5.1347 " ft.	4. bu.	145.3920
Dekaliter	9.081 dry qt.	610.254 " in.	8.813 dry qt.	10.
Deciliter	0.18162 dry pint	6.10254 " "	0.1767 dry pint	0.1
Gallon, U. S.	1. gal.	268.8025 " "	0.9694 gal.	4.4046
Gallon, British*	1.031516 "	277.2738 " "	1. "	4.5435
Hektoliter	2.83783 bu.	3.53156 " ft.	2.7511 bu.	100.
Kiloliter (cu. m.)	28.3783 "	35.3156 " "	27.511 "	1000.
Liter	0.9081 dry qt.	61.0254 " in.	0.8813 qt.	1.
Peck, U. S.	1 peck	537.6050 " "	0.9694 peck	8.8092
Peck, British	1.031516 "	554.548. " "	1. "	9.0870
Pint	1. pint	33.6003 " "	0.9694 pint.	0.5505
Quart	1. qt.	67.2006 " "	0.9694 qt.	1.1010
Quarter, British	8.252128 bu.	10.2694 " ft.	8. bu.	290.781
Wey, British	41.2606 "	51.3470 " "	40. "	1453.92

* See Note Liquid Measure.

MEASURES OF WEIGHT.

EQUIVALENTS OF AVOIRDUPOIS AND METRIC WEIGHTS.

Measures.	Avoirdupois.		Grams or Kgs	
Centrigram	0.15432	grains	0.01	g.
Dekagram	154.32356	grains	10.	g.
Decigram	1.54324	grains	0.1	g.
Dram, U. S. and Brit. Avoir	27.34375	grains	1.7718	g.
Dram, U. S. and Brit. Apoth	60.	grains	3.888	g.
Grain, U. S. and Brit	1.	grain	0.0648	g.
Gram	15.43236	grains	1.	g.
	0.03527	oz.		
Hektogram	3.5274	oz.	100.	g.
Hundredweight, U. S.	100.	lbs.	45.360	kg.
Hundredweight, Brit	112.	lbs.	50.708	kg.
Kilogram	2.20462	lbs.	1000.	g.
Miller, or Tonne	2204.62	lbs.	1000.	kg.
Milligram	0.01543	grains	0.001	g.
Myriagram	22.0462	lbs.	10.	kg.
Ounce, Avoir., U. S. and Brit	437.5	grains	28.3502	g.
Ounce, Troy and Apoth., U. S. and Brit	480.000	grains	31.1035	g.
Pennyweight, Troy, U. S. and Brit	24.	grains	1.5552	g.
Pound, U. S. and Brit. Avoir	1.	lb.	453.6049	g.
	7000.	grains	0.4536	kg.
Pound, U. S. and Brit. Troy and Apoth	0.82286	lbs.	373.2574	g.
	5760.	grains	0.3732	kg.
Quarter, U. S.	25.	lbs.	11.34	kg.
Quarter, Brit	28.	lbs.	12.7	kg.
Quintal, U. S. and Brit	100.	lbs.	45.36	kg.
Quintal, French	220.462	lbs.	100.	kg.
Scruple, U. S. and Brit	20.	grains	1.296	g.
Stone, Brit	14.	lbs.	6.3504	kg.
Ton, U. S. and Brit., long	2240.	lbs.	1016.064	kg.
Ton, U. S., short	2000.	lbs.	907.2	kg.
Tonneau, French	2204.62	lbs.	1000.	kg.

LIQUID MEASURE.

	Cubic Inches.		Pounds Avoir.	
Gill	7.21875	cu. in.	0.2604875	lbs.
Pint	28.875	"	1.04195	"
Quart	57.750	"	2.0839	"
Gallon	231.	"	8.3356	"
Wine Barrel, 31½ gals	7276.5	"	262.5714	"
Beer Barrel, 31 gals	7161.	"	258.4036	"

DRY MEASURE.

Dry gal. = 1.16365 liquid gal. Liter = 0.26417 U. S. gal. = 2.202 lbs. water at 62° = 0.28377 bu.

	Cubic Inches.	Pounds Avoir.
Pint	33.6003	1.21234
Quart	67.2006	2.42468
Gallon	268.8025	9.69872
Peck	537.6050	19.39744
Bushel, struck	2150.4200	77.58976

WEIGHT OF WATER.

(Approximately.)

Standard temperature 62° F.; 1 cu. ft. water = 62.5 lbs. avoir.

CONVERSION TABLES.

Common to Metric Measure.

LINEAR.

Fractions of an inch to millimeters.

1 inch = 25.4 (25.399541) mm.

$\frac{1}{16}$ = 1.587 mm.	$\frac{3}{8}$ = 9.525 mm.	$\frac{11}{16}$ = 17.462 mm.
$\frac{1}{8}$ = 3.175 mm.	$\frac{7}{16}$ = 11.112 mm.	$\frac{3}{4}$ = 19.050 mm.
$\frac{3}{16}$ = 4.762 mm.	$\frac{1}{2}$ = 12.700 mm.	$\frac{13}{16}$ = 20.637 mm.
$\frac{1}{4}$ = 6.350 mm.	$\frac{9}{16}$ = 14.287 mm.	$\frac{7}{8}$ = 22.225 mm.
$\frac{5}{16}$ = 7.937 mm.	$\frac{5}{8}$ = 15.875 mm.	$\frac{15}{16}$ = 23.812 mm.

To obtain centimeters, move decimal point one place to the left. For higher metric measures, move decimal point accordingly.

	Inches to Millimeters.	Feet to Meters.	Yards to Meters.	Miles to Kilometers.
1 =	25.4001	0.304801	0.914402	1.60935
2 =	50.8001	0.609601	1.828804	3 21869
3 =	76.2002	0 914402	2 743205	4.82804
4 =	101.6002	1.219202	3.657607	6.43739
5 =	127.0003	1.524003	4.572009	8.04674
6 =	152.4003	1.828004	5.486411	9.65608
7 =	177.8004	2.133604	6.400813	11.26543
8 =	203.2004	2.438405	7.315215	12.87478
9 =	228.6005	2.743205	8.229616	14.48412

To obtain other metric measures, move decimal point accordingly, thus: 1 foot = 0.304801 meters = 3.04801 decimeters = 30.4801 centimeters = 304.801 millimeters, or 1 foot = 0.304801 meters = 0.0304801 decameters = 0.00304801 hectometers = 0.000304801 kilometers.

SQUARE.

	Square Inches to Square Centimeters.	Square Feet to Square Decimeters.	Square Yards to Square Meters.	Acres to Hectares.
1 =	6.452	9.290	0.836	0.4047
2 =	12.903	18.581	1.672	0.8094
3 =	19.355	27.871	2.508	1.2141
4 =	25.807	37.161	3.344	1.6187
5 =	32.258	46.452	4.181	2.0234
6 =	38.710	55.742	5.017	2.4281
7 =	45.161	65 032	5.853	2.8328
8 =	51.613	74.323	6.689	3.2375
9 =	58.065	83.613	7 525	3.6422

CUBIC.

	Cubic Inches to Cubic Centimeters.	Cubic Feet to Cubic Meters.	Cubic Yards to Cubic Meters.	Bushels to Hectoliters.
1 =	16.387	0.[illegible]	0.765	0.[illegible]
2 =	32.774	0.05[illegible]	1.[illegible]	0.70[illegible]
3 =	49.161	0.08[illegible]	2.294	1.[illegible]
4 =	65.549	0.11327	3.058	1.[illegible]
5 =	81.936	0.14158	3.823	1.76[illegible]
6 =	98.323	0.16990	4.587	2.11[illegible]
7 =	114.710	0.19[illegible]	5.352	2.[illegible]
8 =	131.097	0.22654	6.116	2.81[illegible]
9 =	147.484	0.25485	6.881	3.17[illegible]

CAPACITY.

	Fluid Drams to Milliliters or Cubic Centimeters.	Fluid Ounces to Milliliters	Quarts to Liters.	Gallons to Liters.
1=	3.70	29.57	0.94636	3.78543
2=	7.39	59.15	1.89272	7.57087
3=	11.09	88.72	2.83908	11.35[illegible]
4=	14.79	118.29	3.78543	15.14174
5=	18.48	147.87	4.73180	18.92717
6=	22.18	177.14	5.67816	22.71261
7=	25.88	207.02	6.62452	26.49804
8=	29.57	236.59	7.57088	30.28348
9=	33.27	266.16	8.51724	34.06891

WEIGHT.

	Grains to Milligrams.	Avoirdupois Ounces to Grams.	Avoirdupois Pounds to Kilograms.	Troy Ounces to Grams.
1=	64.7989	28.3495	0.45359	31.10348
2=	129.5978	56.6991	0.90719	62.20696
3=	194.3968	85.0486	1.36078	93.31044
4=	259.1957	113.3981	1.81437	124.41392
5=	323.9946	141.7476	2.26796	155.51740
6=	388.7935	170.0972	2.72156	186.62088
7=	453.5924	198.4467	3.17515	217.72437
8=	518.3914	226.7962	3.62874	248.82785
9=	583.1903	255.1457	4.08233	279.93133

Metric to Common Measure.

LINEAR.

	Meters to Inches.	Meters to Feet.	Meters to Yards.	Kilometers to Miles.
1 =	39.3700	3.28083	1.093611	0.62137
2 =	78.7400	6.56167	2.187222	1.24274
3 =	118.1100	9.84250	3.280833	1.86411
4 =	157.4800	13.12333	4.374444	2.48548
5 =	196.8500	16.40417	5.468056	3.10685
6 =	236.2200	19.68500	6.561667	3.72822
7 =	275.5900	22.96583	7.655278	4.34959
8 =	314.9600	26.24667	8.748889	4.97096
9 =	354.3300	29.52750	9.842500	5.59233

[redacted]

SQUARE.

	Square Centimeters to Square Inches.	Square Meters to Square Feet.	Square Meters to Square Yards.	Hectares to Acres.
1 =	0 1550	10.764	1.196	2.471
2 =	0.3100	21.528	2.392	4.942
3 =	0.4650	32.292	3.588	7.413
4 =	0.6200	43.055	4.784	9.884
5 =	0.7750	53.819	5.980	12 355
6 =	0.9300	64 583	7.176	14.826
7 =	1.0850	75.347	8.372	17.297
8 =	1.2400	86.111	9 568	19.768
9 =	1.3950	96.875	10.764	22.239

CUBIC.

	Cubic Centimeters to Cubic Inches.	Cubic Decimeters to Cubic Inches.	Cubic Meters to Cubic Feet.	Cubic Meters to Cubic Yards.
1 =	0.0610	61.023	35.314	1.308
2 =	0.1220	122.047	70.629	2.616
3 =	0.1831	183.070	105.943	3 924
4 =	0.2441	244.094	141.258	5.232
5 =	0.3051	305.117	176.572	6.540
6 =	0 3661	366.140	211.887	7.848
7 =	0.4272	427.164	247.201	9.156
8 =	0.4882	488.187	282.516	10.464
9 =	0.5492	549.210	317.830	11.771

CAPACITY.

	Milliliters or Cubic Centimeters to Fluid Drams.	Centiliters to Fluid Ounces.	Liters to Quarts.	Decaliters to Gallons.	Hectoliters to Bushels.
1 =	0.27	0.338	1 0567	2.6417	2.8377
2 =	0.54	0.676	2 1134	5.2834	5.6755
3 =	0 81	1.014	3.1700	7.9251	8.5132
4 =	1.08	1 353	4.2267	10.5668	11.3510
5 =	1.35	1.691	5.2834	13.2085	14.1887
6 =	1.62	2.029	6.3401	15.8502	17.0265
7 =	1.89	2.367	7.3968	18.4919	19.8642
8 =	2.16	2.705	8.4535	21.1336	22.7019
9 =	2.43	3.043	9.5101	23.7753	25.5397

WEIGHT.

	Milligrams to Grains.	Kilograms to Grains.	Hectograms to Ounces Avoirdupois.	Kilograms to Pounds Avoirdupois.
1 =	0.01543	15432.36	3.5274	2.20462
2 =	0.03086	30864.71	7.0548	4.40924
3 =	0.04630	46297.07	10.5822	6.61387
4 =	0.06173	61729 43	14.1096	8.81849
5 =	0 07716	77161.78	17.6370	11.02311
6 =	0.09259	92594.14	21.1644	13.22773
7 =	0.10803	108026.49	24.6918	15.43236
8 =	*0.12346*	123458.85	28.2192	17.63698
9 =	*0 13889*	138891.21	31.7466	19 84160

	Quintals to Pounds Av.	Milliers or Tonnes to Pounds Av.	Kilograms to Ounces Troy.
1 =	220.46	2204.6	32.1507
2 =	440.92	4409.2	64.3015
3 =	661.39	6613.9	96.4522
4 =	881.85	8818.5	128.6030
5 =	1102.31	11023.1	160.7537
6 =	1322.77	13227.7	192.9044
7 =	1543.24	15432.4	225.0552
8 =	1763.70	17637.0	257.2059
9 =	1984.16	19841.6	289.3567

MISCELLANEOUS.

1 Gunter's chain = 20.1168 meters.
1 sq. statute mile = 259.000 hectares.
1 fathom = 1.829 meters.
1 nautical mile = 1853.25 meters.
1 foot = 0.304801 meter.
1 avoir. pound = 453.5924277 gram.
15432.35639 grains = 1 kilogram.

A CUBIC INCH IS EQUAL TO

16.38663 milliliters; or 1.638663 centiliters; or 0.1638663 deciliter; or 0.01638663 liter; or to 0.0005787 cubic ft.; or to 0.138528 U. S. gill; or 1.90985 spherical in.

A CUBIC YARD IS EQUAL TO

27 cu. ft. or to 201.974 U. S. gals.
46656 cu. in.
0.0764534 myrialiter.
0.764534 kiloliter, or cu. meter.
7.64534 hectoliters.
7.2 flour barrels of 3 struck bushels.
76.4534 decaliters.
764.534 liters, or cu. decimeters.
7645.34 deciliters.
21.69623 U. S. bushels (struck).
21.03336 Brit. bushels.

POUNDS IN A BUSHEL.

Articles.	California.	Connecticut.	Delaware.	Illinois.	Indiana.	Iowa.	Kentucky.	Louisiana.	Maine.	Massachusetts.	Michigan.	Minnesota.	Missouri.	N. Hampshire.	New Jersey.	New York.	Ohio.	Oregon.	Pennsylvania.	Rhode Island.	Vermont.	Washington T.	Wisconsin.
Barley	50	—	—	48	48	48	48	32	—	46	48	48	48	—	48	48	48	46	47	—	46	45	48
Corn	52	56	56	52	56	56	56	56	—	56	56	56	52	—	56	58	56	56	56	—	56	56	56
Corn in ear	—			70	68	68	—	—				—	—	—			—	—	—	—	—	—	—
Corn Meal	—		—	48	50		50	—	50	50	—	—			—	—	—	—	—	50	—	—	—
Coal	—	—		80	70			—		—	—	—	80		—		—	—	—		—	—	—
Oats	32	28	—	32	32	35	33⅓	32	30	30	32	32	35	30	30	32	32	34	32	—	3	36	32
Potatoes	—	60	—	60	60	60	60	—	60	—	—		60	60	6	60	—	60	—	60	60	60	60
Rye	54	56	—	54	56	56	56	[illegible]	—	56	56	56	56	—	56	56	56	56	56	—	56	56	56
Rye Meal	—		—	—		—		—	50	50	—		—	—	—	—	—	—	—	50	—	—	—
Salt	—	—	—	—	50	50	50		—	—	—	—	50	—	—	56		—	—	—	—	—	—
Wheat	60	56	60	60	60	60	60	60		60	[illegible]	60	60		60	60	60	60	60	—	60	60	60
Wheat Bran	—	—	—	20	—	20	20		—	—		—	20	—	—	—	—	—		—	—	—	—

WEIGHTS OF GRAINS AND OTHER ARTICLES.

The table on page 102 gives a few of the weights by volume fixed by statute in many of the states of the Union. These weights are understood in buying and selling in the respective states, unless other values are specifically agreed upon.

COMPOUND UNITS.

PRESSURES AND WEIGHTS.

1 lb. per square inch (453.59 g.)	=	144 lbs. per square foot. 2.0355 in. of mercury at 32° F. 2.0416 in. of mercury at 62° F. 2.309 ft. of water at 62° F. 27.71 in. of water at 62° F.
1 atmosphere (14.7 lbs., or 6.6679 kg. per sq. in.)	=	2116.3 lbs. per square foot. 33.947 ft. of water at 62° F. 30 in. of mercury at 62° F. 29.922 in of mercury at 32° F. 760 millimeters of mercury at 32° F
1 inch of water at 62° F.	=	0 0361 lb. per square inch. 5.196 lbs. per square foot. 0.0736 in. of mercury at 62° F.
1 inch of water at 32° F.	=	5.2021 lbs. per square foot. 0.036125 lbs. per square inch.
1 foot of water at 62° F.	=	0.433 lb. per square inch. 62.355 lbs per square foot. 0.883 in. of mercury at 62° F.
1 inch of mercury at 62° F. (2.54 cm.)	=	0.49 lb. per square inch. 70.56 lbs. per square foot. 1.132 ft. of water at 62° F. 13.58 ins. of water at 62° F.

1 kilogram per square inch = 317.46 lbs. per square foot.
1 kilogram per square centimeter = 14.223 lbs. per square inch.
1 ton per square inch = 157.49 kilograms per square centimeter.
1 pound per square inch = 0.07031 kg. per sq. cm.
1 kilogram per square centimeter = 14.223 lbs, per sq. in.

POWER AND WORK.

"Work," in a mechanical sense, is the sustained exertion of pressure through space. The unit for measuring it is the "foot-pound" (ft.-lb.), being a pressure of one pound exerted through a space of one foot, or in the metric system, a "kilogrammeter" (m. kg.), being a pressure of one kilogram through a space of one meter.

1 ft.-lb. = 0.138 m. kg.

(For explanation of horse-power and heat unit see chapter "Power.")

1 horse-power = 1.0139 Cheval-Vapeur (metric horse-power).
1 ft.-lb. = 0.13825 kilogrammeter.
1 *Cheval-Vapeur* = *0.9863* horse-power.
1 kilogrammeter = *7.223* ft.-lbs.

1 caloric (metric heat-unit) = 3.968 heat-unit (B. T. U.).

1 heat-unit = 0.252 caloric.

1 U. S. mechanical equivalent or 1 joule (772 ft.-lbs.) = 106.733 kilogrammeters.

1 heat-unit per sq. ft. = 0.2713 caloric per sq. m.

VELOCITY.

1 foot per second = 3600 ÷ 5280 or 0.6818 inches per hour.

1 foot per second, minute, etc. = 0.3047 meter per second.

1 mile per hour = 0.447 meter per second.

(For measures of temperature see "The Brewer's Chemical Laboratory.")

MEASURES OF TIME.

60 seconds = 1 minute.
60 minutes = 1 hour.
24 hours = 1 day.
365 days = 1 common year.
366 days = 1 leap year.

In civil computation, i. e., for all the practical purposes of life, the day commences at midnight and is divided into two portions of 12 hours each, from midnight to noon, and from noon to midnight.

In nautical time and astronomical computation the day begins at noon. In nautical time the day is divided into watches of 4 hours each. In astronomical time the day is counted through the 24 hours.

A "solar day" is measured by the rotation of the earth upon its axis with respect to the sun.

A "solar year" is the time in which the earth makes one revolution around the sun. Its average time, or the "mean solar year" is 365 days, 5 hours, 48 minutes, 49.7 seconds, or nearly 365¼ days. A "mean lunar month" is 29 days, 12 hours, 44 minutes, 2 seconds and 5.24 thirds.

By the *Julian* (or old style) *Calendar*, introduced by Julius Cæsar, the year was taken as 365 days, 6 hours. To equalize the loss of time, one extra day was inserted every fourth year (leap year), being placed at the end of February. The slight difference between the length of the year assumed in the Julian Calendar and the actual length of the year, amounting to 11 minutes, 12 seconds every year, had accumulated to a period of 10 days at the time of Pope Gregory XIII, who suppressed 10 days out of

the year 1582, going from October 5 to 15. In the Reformed or Gregorian (new style) Calendar, the repetition of this accumulation of error is prevented by leaving out 3 of the extra days every 400 years, making this omission in the years which are not exactly divisible by 400. Thus of the leap years 1700, 1800, 1900, 2000, only the last is made leap year. This Gregorian Calendar was introduced in England in 1752, when 11 days were omitted. It is now in force in all Christian countries, except Russia, which is 12 days behind the rest in its time.

LEGAL UNITS OF ELECTRICAL MEASURE.

In accordance with a resolution adopted by the International Electrical Congress, held at Chicago, in 1893, the Congress of the United States has established the following units of electrical measure:

First. The unit of resistance shall be what is known as the international "ohm," which is substantially equal to one thousand million units of resistance of the centimeter-gram-second system of electro-magnetic units, and is represented by the resistance offered to an unvarying electric current by a column of mercury at the temperature of melting ice fourteen and four thousand five hundred and twenty-one ten-thousandths grams in mass, of a constant cross-sectional area, and of the length of one hundred and six and three-tenths centimeters.

Second. The unit of current shall be what is known as the international "ampere," which is one-tenth of the unit of current of the centimeter gram-second system of electro-magnetic units, and is the practical equivalent of the unvarying current, which, when passed through a solution of nitrate of silver in water in accordance with standard specifications, deposits silver at the rate of one thousand one hundred and eighteen millionths of a gram per second.

Third. The unit of electro-motive force shall be what is known as the international "volt," which is the electro-motive force that, steadily applied to a conductor whose resistance is one international ohm, will produce a current of an international ampere, and is practically equivalent to one thousand fourteen hundred and thirty-fourths of the electro-motive force between the poles or electrodes of the voltaic cell known as Clark's cell, at a tem-

perature of fifteen degrees centigrade, and prepared in the manner described in the standard specifications.

Fourth. The unit of quantity shall be what is known as the international "coulomb," which is the quantity of electricity transferred by a current of one international ampere in one second.

Fifth. The unit of capacity shall be what is known as the international "farad," which is the capacity of a condenser charged to a potential of one international volt by one international coulomb of electricity.

Sixth. The unit of work shall be the "joule," which is equal to ten million units of work in the centimeter-gram-second system, and which is practically equivalent to the energy expended in one second by an international ampere in an international ohm.

Seventh. The unit of power shall be the "watt," which is equal to ten million units of power in the centimeter-gram-second system, and which is practically equivalent to the work done at the rate of one joule per second.

Eighth. The unit of induction shall be the "henry," which is the induction in a circuit when the electro-motive force induced in this circuit is one international volt, while the inducing current varies at the rate of one ampere per second.

MONEY.

UNITED STATES.

Nominally there are two units of value.

The gold unit of value is the gold dollar which contains 25.8 grains of standard gold 0.900 fine. The amount of fine gold in the dollar is 23.22 grains, and the remainder of the weight is an alloy of copper. No more $1 gold pieces have been coined since the Act of September 26, 1890. Gold is now coined in denominations of $2.50, $5, $10 and $20, called, respectively, quarter eagles, half eagles, eagles and double eagles.

The silver unit is the standard dollar which contains 412½ grains of standard silver 0.900 fine. The amount of fine silver in the dollar is 371¼ grains, and there are 41¼ grains of copper alloy.

1 eagle = 10 dollars ($) = 100 dimes = 1,000 cents, c.
1 dollar = 10 dimes = 100 cents, c.
1 dime = 10 cents, c.

Subsidiary coins are: Half dollar = 50 cents, quarter dollar = 25 cents; dime = 10 cents, all in silver.

Minor coins are: Five cents (nickel) and 1 cent (copper).

There remain in circulation small amounts of coins no longer coined, and being gradually withdrawn, as: Trade dollar, nominally worth 100 cents, but in reality much less; twenty cents (silver); half dime (silver); three cents (nickel); two cents (copper).

DENOMINATIONS, WEIGHT AND FINENESS OF THE COINS OF THE UNITED STATES.

GOLD.

Denomination.	Fine Gold Contained.	Alloy Contained.*	Weight.
	Grains.	Grains.	Grains.
One dollar ($1)	23.22	2.58	25.80
Quarter eagle ($2.50)	58.05	6 45	64.50
Three dollars ($3)	69.66	7.74	77.40
Half eagle ($5)	116.10	12.90	129.00
Eagle ($10)	232.20	25.80	258.00
Double eagle ($20)	464.40	51.60	516.00

*The alloy neither adds to nor detracts from the value of the coin.

SILVER.

Denomination.	Fine Silver Contained.	Alloy Contained.	Weight.
	Grains.	Grains.	Grains.
Standard dollar	371.25	41.25	412.50
Half dollar	173.61	19.29	192.90
Quarter dollar	86.805	9.645	96.45
Dime	34.722	3.858	38.58

MINOR.

Denomination.	Fine Copper Contained.	Alloy Contained.	Weight.
	Grains.	Grains.	Grains.
Five cents*	57.87	19.29	77.16
One cent†	45.60	2.40	48.

*Seventy-five per cent copper, 25 per cent nickel.
†Ninety-five per cent copper, 5 per cent tin and zinc.

Troy weights are used, and while metric weights are by law assigned to the half and quarter dollar and dime, troy weights still

continue to be employed, 15.432 grains being considered as the equivalent of a gram, agreeably to the Act of July 28, 1866.

The weight of $1,000 in United States gold coin is 53.75 troy ounces, equivalent to 3.68 pounds avoirdupois. The weight of $1,000 in standard silver dollars is 859.375 troy ounces, equivalent to 58.92 pounds avoirdupois, and the weight of $1,000 in subsidiary silver is 803.75 troy ounces, equivalent to 55.11 pounds avoirdupois.

REDEMPTION.

Gold coins and standard silver dollars, being standard coins of the United States, are not "redeemable."

Subsidiary coins and minor coins may be presented, in sums or multiples of twenty dollars, to the treasurer of the United States or to an assistant treasurer for redemption or exchange into lawful money.

United States notes are redeemable in "coin," in sums not less than $50, by the assistant treasurers in New York and San Francisco.

Treasury notes of 1890 are redeemable in "coin," in sums not less than $50, by the treasurer and all assistant treasurers of the United States.

National bank notes are redeemable in lawful money of the United States by the treasurer, but not by the assistant treasurers. They are also redeemable at the bank of issue. In order to provide for the redemption of its notes when presented, every national bank is required by law to keep on deposit with the treasurer a sum equal to 5 per cent of its circulation.

Gold certificates being receipts for gold coin, are redeemable in such coin by the treasurer and all assistant treasurers of the United States.

Silver certificates are receipts for standard silver dollars deposited, and are redeemable in such dollars only.

"Coin" obligations of the government are redeemed in gold coin when gold is demanded, and in silver when silver is demanded.

COINS AND PAPER CURRENCY.

There are ten different kinds of money in circulation in the United States, namely, gold coins, standard silver dollars, subsidiary silver, gold certificates, silver certificates, treasury notes is-

[redacted]

sued under the Act of July 14, 1890, United States notes (also called greenbacks and legal tenders), national bank notes, and nickel and bronze coins. These forms of money are all available as circulation. While they do not all possess the full legal-tender quality, each kind has such attributes as to give it currency. The status of each kind is as follows:

Gold coin is legal tender at its nominal or face value for all debts, public and private, when not below the standard weight and limit of tolerance prescribed by law; and when below such standard and limit of tolerance it is legal tender in proportion to its weight.

Standard silver dollars are legal tender at their nominal or face value in payment of all debts, public and private, without regard to the amount, except where otherwise expressly stipulated in the contract.

Subsidiary silver is legal tender for amounts not exceeding $10 in any one payment.

Treasury notes of the Act of July 14, 1890, are legal tender for all debts, public and private, except where otherwise expressly stipulated in the contract.

United States notes are legal tender for all debts, public and private, except duties on imports and interest on the public debt.

Gold certificates, silver certificates, and national bank notes are not legal tender, but both classes of certificates are receivable for all public dues, while national bank notes are receivable for all public dues except duties on imports, and may be paid out by the government for all salaries and other debts and demands owing by the United States to individuals, corporations, and associations within the United States, except interest on the public debt and in redemption of the national currency. All national banks are required by law to receive the notes of other national banks at par.

The minor coins of nickel and copper are legal tender to the extent of 25 cents.

FOREIGN COINS.

The following values are given in a circular of January 1, 1901, by George E. Roberts, director of the United States mint, for foreign as compared with United States coins:

VALUES OF FOREIGN COINS.

Country.	‡Standard.	Monetary Unit	Value in terms of U. S. Gold dollar.	Coins.
Argentine Republic	G.	Peso	$0.965	Gold: Argentine ($4.824) and ½ Argentine. Silver: peso and divisions.
Austria-Hungary	G.	Crown	0.203	Gold: former system—4 florins ($1.929), 8 florins ($3.858), ducat ($2.287), and 4 ducats ($9.149. Silver: 1 and 2 florins Gold: present system—20 crowns ($4.052); 10 crowns ($2.026).
Belgium	G.	Franc	0.193	Gold: 10 and 20 francs. Silver: 5 francs.
Bolivia	S.	Boliviano	0.468	Silver: boliviano and divisions.
Brazil	G.	Milreis	0.546	Gold: 5, 10, and 20 milreis. Silver: ½, 1, and 2 milreis.
British possessions N. A. (except Newfoundland)	G.	Dollar	1.000	
Central American States—Costa Rica	G.	Colon	0.465	Gold: 2, 5, 10, and 20 colons ($9.307). Silver: 5, 10, 25, and 50 centimos.
British Honduras.	G	Dollar.	1.000	
Guatemala, Honduras, Nicaragua, Salvador	S.	Peso	0.468	Silver: peso and divisions.
Chile	G.	Peso	0.365	Go'd: escudo ($1,825), doubloon ($3.650), and condor ($7.300). Silver: peso and divisions.
China	S.	Tael.		
		Amoy	0.757	
		Canton	0.755	
		Chefoo	0.724	
		Chin Kiang	0.740	
		Fuchau	0.701	
		Haikwan (Customs)	0.771	
		Hankow	0.709	
		Hong-kong	(*)	
		Niuh-chwang	0.710	
		Ningpo	0.728	
		Shanghai	0.692	
		Swatow	0.700	
		Takau	0.762	
		Tientsin	0 734	
Colombia	S.	Peso	0.468	Gold: condor ($9.647) and double-condor. Silver: peso.

*The "British dollar" has the same legal value as the Mexican dollar in *Hongkong, the Straits* Settlements, and Labuan.

‡*G—gold. S—silver.*

VALUES OF FOREIGN COINS—Continued.

Country.	‡Standard.	Monetary Unit	Value in terms of U. S. gold dollar.	Coins.
Cuba	G.	Peso	0 926	Gold: Doubloon Isabella, centen ($5 017). Alphonse ($4.823). Sil.: peso.
Denmark	G.	Crown	0.268	Gold: 10 and 20 crowns.
Ecuador	S.	Sucre	0.468	Gold: condor ($9.647) and double-condor. Silver: sucre and divisions.
Egypt	G.	Pound (100 piasters).	4 943	Gold: pound (100 piasters), 5, 10, 20, and 50 piasters. Silver: 1, 2, 5, 10, and 20 piasters.
Finland	G.	Mark	0.193	Gold: 20 marks ($3.859), 10 marks ($1.93).
France	G.	Franc	0.193	Gold: 5, 10, 20, 50, and 100 francs. Silver: 5 francs.
German Empire.	G.	Mark	0.238	Gold: 5, 10, and 20 marks.
Great Britain	G.	Pound sterling.	4.866½	Gold: sovereign (pound sterling) and ½ sovereign.
Greece	G.	Drachma	0.193	Gold: 5, 10, 20, 50, and 100 drachmas. Silver: 5 drachmas.
Haiti	G.	Gourde	0 965	Gold: 1, 2, 5, and 10 gourdes. Silver: gourde and divisions.
India	G.	Rupee†	0.324	Gold: Sovereign ($4.8665). Silver: rupee and divisions.
Italy	G.	Lira	0.193	Gold: 5, 10, 20, 50, and 100 lire. Silver: 5 lire.
Japan	G.	Yen	0.498	Gold: 5, 10, and 20 yen. Silver: 10, 20, and 50 sen.
Liberia	G.	Dollar	1.000	
Mexico	S.	Dollar	0.509	Gold: dollar ($0.983), 2½, 5, 10, and 20 dollars. Silver: dollar (or peso) and divisions.
Netherlands	G.	Florin	0.402	Gold: 10 florins. Silver: ½, 1, and 2½ florins.
Newfoundland	G.	Dollar	1.014	Gold: 2 dollars ($2 027).
Norway	G.	Crown	0.268	Gold: 10 and 20 crowns.
Persia	S.	Kran	0.086	Gold: ½, 1 and 2 tomans ($3.409). Silver: ¼, ½, 1, 2, and 5 krans.
Peru	G.	Sol	0.487	Gold: libra ($4.8665). Silver: sol and divisions.
Portugal	G.	Milreis	1.080	Gold: 1, 2, 5, and 10 milreis.
Russia	G.	Ruble	0.515	Gold: imperial, 15 rubles ($7.718), and ½ imperial, 7½ rubles ($3 859). Silver: ¼, ½, and 1 ruble.
Spain	G.	Peseta	0.193	Gold: 25 pesetas. Silver: 5 pesetas.
Sweden	G.	Crown	0.268	Gold: 10 and 20 crowns.
Switzerland	G.	Franc	0 193	Gold: 5, 10, 20, 50, and 100 francs. Silver: 5 francs.
Turkey	G.	Piaster	0 044	Gold: 25, 50, 100, 250, and 500 piasters.
Uruguay	G.	Peso	1.034	Gold: Peso. Silver: Peso and divisions.
Venezuela	G.	Bolivar	0.193	Gold: 5, 10, 20, 50, and 100 bolivars. Silver: 5 bolivars.

*The "British dollar" has the same legal value as the Mexican dollar in Hongkong, the *Straits Settlements*, and Labuan.

†*The sovereign is the* standard coin of India, but the rupee is the money *of account, current at 15 to the* sovereign.

‡*G—gold, S—silver.*

PHYSICS.

Physics, popularly called "Natural Philosophy," is that science which treats of such changes in bodies as do not permanently affect the properties of such bodies (new bodies are not formed). A lump of sulphur can be reduced to a powder by grinding, melted by careful heating, made electric by rubbing with a woolen cloth; but, after all these changes, still remains sulphur, and such changes, therefore, belong to the domain of physics. But if sulphur is ignited it burns with a pale blue flame, emitting a suffocating odor, it disappears, and is no longer sulphur (new bodies are formed). Such a change is not a physical change, but a chemical, and the study of such a change belongs to the science of chemistry.

"Matter" is anything that takes up space or has weight. Different kinds of matter are, f. i., earth, metals, animal and vegetable substances, water, air and other gases. Air is matter because it has weight and takes up space. One cubic foot of air weighs 1.3 oz., whereas one cubic foot of water weighs 1000 oz., or 773 times as much.

STATES OF MATTER.

Matter occurs in three states, solid, fluid and gaseous. Many substances are met with in nature in all three of those states. Water is solid ice below 32° F., fluid water from 32° F. to 212° F., above 212° F. water is in the state of a gas and is called steam. If the heat is high enough, all substances will take the form of a gas, even metals, such as zinc, iron, gold, etc.

"Solids" are bodies that have a strong tendency to keep the same shape in all positions.

"Fluids" are bodies whose shapes depend on the vessels that contain them.

"Gases" are bodies that have a tendency to occupy as large a space as possible, and exert a pressure or tension on the vessels that contain them.

"Molecules." The fact that all bodies expand by heat, and that they can be changed from solids to fluids and gases, can be easily explained, if we suppose that all bodies are composed of very small, separate, and movable particles. To these small particles the name "molecules" has been given. A molecule is so extremely small that the most minute particle of dust floating in the air contains millions of molecules.

FORCES.

Matter is constantly undergoing changes of different kinds. All causes tending to change the condition of rest or motion of a body are called "forces," such as gravitation, sound, light, heat, magnetism, electricity, etc.

Force, like matter, is indestructible; both can change form, but the total amount of matter and force in the universe is always the same. By heat we may change ice to water, water to steam, and thus make it invisible, but every molecule of the water is present in the steam, and can be gathered and reduced to water and ice again by cooling. And an amount of heat equal to that which is consumed in bringing about the change of boiling hot water to steam is set free again when the steam is condensed to water.

We suppose that the molecules are held together by a certain force called "cohesion." This force is strong enough in solid bodies to keep the molecules together. In the fluids, cohesion is weaker and allows the molecules a freer movement; and in the gases, the molecules being far apart, cohesion entirely disappears, the scattered molecules moving further and further apart until arrested by some other body, on which they then exert a pressure called the tension of the gases.

PROPERTIES OF MATTER.

"Extension." Matter occupies space; it is measured by its length, breadth, and thickness, called the three dimensions. This property or quality of matter is expressed by the word extension.

"Mass and Weight." The amount of matter of a body is called its mass. *The weight of* a body is the measure of the attraction *exercised upon it by the* earth. The mass of a body is the same

in all positions, the weight of a body depends on its distance from the surface of the earth.

"Impenetrability." The fact that two bodies cannot be in the same place at the same time is expressed by the term impenetrability of matter. If an inverted bottle is immersed in water, the water cannot rise into the bottle to fill it on account of the presence of air in the bottle.

"Indestructibility" of matter signifies that matter cannot be destroyed. The amount of matter in the universe cannot be decreased.

"Inertia" is the tendency of matter to remain in the same condition, that is, if at rest, to remain so, and if in motion, to continue to move with unchanged speed in the same direction.

"Elasticity" is the property of matter to resist pressure, pulling, bending or twisting, and to resume its original form when the force ceases to act upon it.

A solid body, like rubber, has elasticity of volume and form, that is, it regains its original form and volume when the force ceases to act on it; fluids have perfect elasticity of volume but no elasticity of form.

"Porosity." As all bodies are composed of separate small particles, or molecules, they only apparently fill the space they seem to occupy. The interstices between the molecules are called "pores," and bodies are said to have porosity. If a tumbler is entirely filled with water some alcohol can be poured into the water without overflowing the tumbler because the alcohol enters into the spaces between the molecules of the water.

"Hardness" of matter is the property of resisting any attempt to separate its molecules by splitting it. When one body is able to scratch another it is said to be harder than the other.

The hardness of many bodies is increased by heating the body and suddenly cooling it. This process of hardening a body is called "tempering."

Some bodies can be made softer by slow cooling after heating them to a high temperature. This process is called "annealing."

"Tenacity" is the quality of matter to resist a force tending to pull its particles apart from each other.

"Malleability." Some bodies can be hammered or rolled into *sheets, and such* bodies are said to possess malleability. Iron *and, to a still* greater extent, gold can be worked into very fine *sheets.*

"Ductility." Some bodies, f. in., glass, iron, platinum, can be drawn out into very fine wires, and such bodies are called "ductile."

"Solutions." Solid bodies and gases can be changed to fluid form by means of some liquids. A lump of sugar thrown into water or alcohol will gradually disappear, the molecules of the solid sugar distributing themselves between the molecules of the water or alcohol, and the two bodies forming one liquid are called a solution. When a solid is changed to a liquid in such way, there is generally a fall of temperature. The melting of ice or the addition of salt to water produces cold. Usually a liquid will dissolve more of a solid body at a high temperature than it will at a lower.

The quantity of a gas taken up by a fluid varies with the temperature and the pressure, and the lower the temperature of the fluid and the stronger the pressure, the more gas will the fluid take up.

"Crystallization." When a solution in water of sugar, salt, or many other substances, is allowed to dry up slowly, the solid bodies in solution often assume a regular shape, a cube, a pyramid, etc., and such bodies are called crystals Thus salt crystallizes in cubes, alum in pyramids, sugar in prisms.

"Absorption." A few solid bodies have the power of taking up or absorbing gases. Thus charcoal can condense in its pores as much as 90 times its own volume of ammonia gas.

"Diffusion." Some liquids and all gases when brought into mutual contact will penetrate each other and produce a uniform mixture. If alcohol, which is lighter than water, is poured on top of water, the heavier water will in the course of time rise and mix evenly with the alcohol. In the same way carbonic acid, which is one-half again as heavy as air, will gradually mix uniformly with the air. This property of matter is called diffusion.

SPECIFIC GRAVITY

Denotes the weight of a body as compared with an equal bulk or volume of another body adopted as a standard, which is reckoned as a unit. In cases of solids or liquids the standard body is pure water of 39.2° F. The specific gravity of a substance is, therefore, a number explaining how many times the *weight of an equal bulk* of water is contained in the weight of the

substance. One cubic foot of water weighs 62.5 lbs., one cubic foot of iron weighs 487.5 lbs., dividing 487.5 by 62.5 gives a quotient of 7.8, indicating that when equal bulks of iron and water are taken, the iron weighs 7.8 times as much as the water; hence the specific gravity of iron is 7.8.

For determination of specific gravity, hydrometers, saccharometers, picnometers, etc., see "The Brewers' Chemical Laboratory."

ATMOSPHERIC PRESSURE.

Air being a material substance has weight. The surface of the earth is the bottom of an ocean of air, and supports the weight of the entire atmosphere. Every square inch of the earth's surface is, therefore, exposed to a certain pressure which is equal to the weight of the column of air resting on it, and reaching from the surface of the earth up to where the air ends. The lower strata of the air, i. e., those nearest to the ground, are much denser and heavier than the upper ones, as they are compressed by the weight of the upper strata. The atmospheric pressure is, therefore, less on the top of a high mountain than it is at sea level, since the column of air over the top of the mountain is both shorter and less dense.

At sea level the pressure of the atmosphere is 14.7 lbs. per square inch.

This pressure is exerted on all bodies with equal power in all directions.

In a bottle filled with air the pressure is equal on the outside and on the inside but if the air be withdrawn from the bottle the outside pressure is no longer balanced by any pressure on the inside, and the walls of the bottle will break unless they are very strong.

The surface of an average man's body is about 20 square feet, or 2,880 square inches, and the pressure on his body is 2880 × 14.7 lbs., or 42,366 lbs.

But this pressure on the outside is counteracted by an equal pressure from within.

If one end of an open tube is dipped into water, and the air sucked out at the other end, the water will immediately rise into the tube, and if the air is drawn out completely the water will rise to a height of nearly 34 feet, and no more, because the weight *of a column of water* of such height will balance the weight of *the air.*

The entire atmosphere, therefore, weighs as much as a layer of water surrounding the globe to a depth of 34 feet.

If mercury is used instead of water, the column will be only about 30 inches high, because mercury is 13.5 times denser than water.

When the air is partly or entirely removed from a vessel there is said to be a partial or complete vacuum in the vessel.

WEIGHT OF WATER AT SEA LEVEL OR 30" BAROMETER.

°F.	°R.	Weight 1 Cu. Ft.	Weight 1 Bbl. 31 Gal.
32° F.	0° R.	62.417 Lb.	258.656
*39.2° "	*3.2° "	62.425 "	258.689
50° "	8° "	62.409 "	258.623
60° "	12.4° "	62.367 "	258.448
70° "	16.9° "	62.302 "	258.180
80° "	21.3° "	62.218 "	257.831
90° "	25.8° "	62.119 "	257.421
212° "	80° "	59.7 "	247.397

*Greatest density.

BAROMETER.

A barometer is an instrument used to measure atmospheric pressure.

The mercury-barometer is a glass tube about 36 inches high, the upper end of which is exhausted and closed air-tight, while the lower end is immersed in a vessel of mercury. The atmospheric pressure keeps the tube filled with mercury to a height of about 30 inches, the remaining 6 inches at the top being a complete vacuum. The atmospheric pressure, like the temperature of the air, is constantly changing, and these changes are shown by the rise or fall of the column of mercury in the glass tube.

The "aneroid-barometer" is a portable instrument, without any liquid. It consists of a metallic box, exhausted of air, the walls of which yield under the varying pressure of the air, their movements being transferred to an indicator on a graduated scale.

MOISTURE OF THE AIR.

The air, when in contact with water, absorbs some of it, and vapor of water is, therefore, always present in the atmosphere. The warmer the air is, the more moisture can it hold. In a tropical climate the air may become almost saturated with water *during the rainy season.* But, on the other hand, the air can be

hot and still very dry, if it rests over a surface devoid of water, for instance, the great desert region of Sahara.

If warm and moist air is gradually cooled down it finally reaches a temperature at which it can no longer hold all the moisture, but deposits some of it in liquid form as dew, fog or clouds, as the case may be.

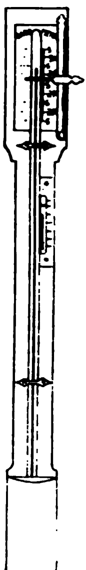


Fig. 1—Mercury Barometer.

Fig. 2—Aneroid Barometer.

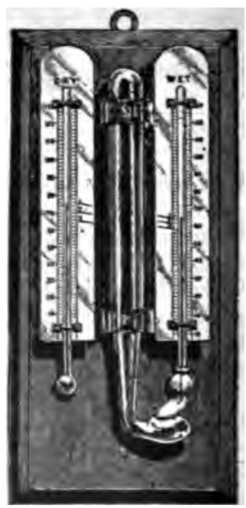


Fig. 3—Hygrometer (wet bulb.)

DEW POINT.

The temperature at which this precipitation takes place is called the dew point, and indicates the temperature at which the moisture present would be sufficient to saturate the air completely.

The less moisture the air contains, the further must it *be cooled down before* this precipitation of water takes place, i. e., *the lower is the* dew point.

HYGROMETER.

There are various methods of finding the amount of moisture in the air, and the instruments used for this purpose are called hygrometers.

One is based upon the fact that water will evaporate faster in dry air than in moist. This instrument consists of two thermometers, one of which indicates the actual temperature of the air. The bulb of the other thermometer is covered with muslin which is kept wet with water; the evaporation produces cold and the thermometer soon sinks below the actual temperature of the air. When it comes to rest the degree is noted, the difference in temperature between the two thermometers is taken, and the amount of moisture in the air found from tables made up for this purpose.

This instrument is known as the "wet-bulb hygrometer."

Another common hygrometer is the "hair hygrometer" in which the variations of moisture in the air are indicated by a hair, previously freed from oily matter, and which stretches when moist and contracts when dry, the movements being transferred to an indicator.

HEAT.

The molecules of all bodies are in continual motion and this motion is what we call "heat." The more rapidly the molecules move, the hotter is the body. If the movement of the molecules should stop entirely the body would have no heat, it would be absolutely cold. Calculations for the gases have led to the conclusion that such a state would be reached at 460 degrees below the zero point of a Fahrenheit thermometer.

When two bodies of different temperatures are brought in contact, the temperature of the warmer one falls while that of the colder one rises, that is, the rapidly moving particles of the warmer body cause the particles of the colder body to move more rapidly than before, while the movements of its own particles are lessened. This process takes place in a similar way as when a fast moving train runs from the rear into one of less speed; the slow train is pushed ahead faster, while the speed of the other is lessened.

"Expansion." An immediate result of the increase in speed of the molecules, which becomes sensible in the form of heat, is

also an increase in their distance from each other, that is, the body expands. By expansion the same mass occupies more space than before, hence displaces more of the surrounding matter and becomes specifically lighter. In a liquid, while being heated, the warmer parts at the bottom will rise to the surface.

"Sources of Heat." The greatest source of heat is the sun, but heat can also be produced by friction, or by chemical changes, as illustrated by the ignition of a common match.

TRANSFER OR DISTRIBUTION OF HEAT.

Heat moves from one point to another in three ways: "conduction," "radiation" and "circulation" (or "convection").

"Conducted Heat." If one end of a bar of iron is held in a fire the temperature will soon rise at the other end of the bar. The heat of the fire has traveled from layer to layer of the bar without any sensible motion of the iron particles.

Heat transmitted in this way is called conducted heat.

A stick of wood may be burning and held in the hand within a short distance of the burning part, whereas a bar of any metal under similar circumstances would burn the hand.

The wood does not conduct the heat so well as do the metals.

Metals are the best conductors of heat, and of the metals silver is the best, then follow copper, gold, tin and iron. The next best conductors are stones, dense woods and charcoal, then liquids in general and, finally, gases which conduct hardly any heat at all.

"Circulation of Heat." Although liquids and gases are poor conductors of heat, they may, nevertheless, be quickly heated, if the heat is applied to the bottoms of the vessels containing them. This heating, however, is not by conduction, but by circulation.

A circulation is set up in the fluid or gas when the portions in contact with the bottom of the vessel get heated, become lighter, and rise to the surface, carrying the heat with them.

"Radiation of Heat." There is another and entirely different way by which heat is transmitted through certain media, and travels with the speed of light, being, in fact, of the same nature as light. Such is the transmission of heat from the sun to the earth, and from any hot body through the air. In this case the heat does not to any extent affect the air through which it

travels it passes between the molecules of the air. Heat that moves in such manner is said to be radiated.

If radiated heat strikes a body too solid to allow it to pass through, the heat is absorbed and raises the temperature of that body.

The light and heat from the sun pass through the atmosphere without warming it, but they heat the earth. From the warm earth, the lower strata of air are then heated by conduction and circulation.

EXPANSION OF SOLIDS.

Nearly all solid bodies expand when heated and contract when cooled. The amount of expansion which different solids undergo depends on the nature of the solid, and the temperature. When heated from 32° F. to 212° F., the expansion in rods of the following substances is:

Firwood	0.000408 $\left(\frac{1}{2450}\right)$
Steel not tempered......	0.001078 $\left(\frac{1}{927}\right)$
Copper	0.00171 $\left(\frac{1}{504}\right)$

that is, a bar of iron, 927 inches long at 32° F., will be one inch longer or 928 inches, when heated to 212° F.

EXPANSION OF LIQUIDS.

The expansion of liquids varies greatly with the nature of the substances. Between 32° F. and 212° F. water expands 0.045 $\left(\frac{1}{22}\right)$ of its original volume, alcohol 0.111 $\left(\frac{1}{9}\right)$. Hence 22 barrels of water at 32° F. will fill 23 barrels at 212° F.

Water forms an exception to the uniformity of progressive expansion with rising temperatures. When heated from 32° F. to 39.2° F., it contracts instead of expanding, and only after reaching the temperature of 39.2° F. does it begin to expand when heated. The temperature of 39.2° F. marks its greatest density, and from this point on it expands whether it is heated or cooled.

EXPANSION OF GASES.

All gases expand nearly alike for an equal increase in temperature, and the increase in volume is independent of the temperature and pressure of the gas. The amount of expansion for a rise in temperature from 32° F. to 212° F. is 0.366 of the original volume.

CHANGE OF STATE.

Many solid bodies when heated are liquified or fused, or they melt. To effect the change from solid to fluid a certain amount of heat is required. If one pound of water of 32° F. and one pound of water of 174° F. are mixed, the temperature of the mixture will be 103° F., or half way between 32° F. and 174° F. But if we mix one pound of ice of 32° F. and one pound of water of 174° F. we will have two pounds of water of 32° F. That is, all the heat given off by the warm water has been just sufficient to melt the ice without producing any rise in temperature. Heat which is absorbed by melting bodies is called "latent heat," or heat of fluidity.

In an exactly similar way heat is absorbed when a fluid is changed into a gas. If we place a thermometer in water that is being heated, the thermometer will constantly rise until it reaches 212° F., at which point it becomes stationary. Any further heat added does not raise the temperature of the boiling water but is entirely consumed in transforming the water into steam.

This heat which is absorbed by the steam is called the "latent heat of vaporization." If steam is condensed to water, this absorbed heat is set free once more. One pound of steam of 212° F., when condensed by being conducted into cold water, gives out heat enough to raise 5.4 pounds of water from 32° F. to 212° F.

"Distillation." If a fluid is made to boil and the vapors are condensed again, the condensed fluid is said to be distilled.

The fluid to be distilled is placed in a vessel, called a retort, generally made of glass or metal, the vapors arising from the boiling fluid pass into a tube, called the worm, which is kept cold by running water, and the condensed vapors flow from the worm into a suitable receiver. The whole apparatus is called a *still*. *If water is treated* this way, the condensed steam turns into

pure water, while the salts and other non-volatile substances remain behind in the retort.

"Sublimation." A few solid bodies, when heated, boil before they melt, and consequently pass directly over from the solid to the gaseous state. Such a change is called sublimation. Solid carbonic acid for instance is such a body and when lying in the open air it passes directly into a gas.

BOILING POINT OF WATER.

Height Above Sea Level.	Barometric Indication.	Boils, Degrees F.	Boils, Degrees R.
15,221 Feet.	16.79 Inches.	184° F.	67 6° R.
10,127 "	20.39 "	193° "	71.6° "
9 031 "	21.26 "	195° "	72.4° "
7,932 "	22.17 "	197° "	73.3° "
6,843 "	23.11 "	199° "	74 2° "
6,304 "	23.59 "	200° "	74 7° "
5,225 "	24.58 "	202° "	75 6° "
4,169 "	25.59 "	204° "	76.4° "
3,115 "	26.64 "	206° "	77 3° "
2,063 "	27.73 "	208° "	78.2° "
1,539 "	28.29 "	209° "	78.7° "
1,025 "	28.85 "	210° "	79.1° "
512 "	29.42 "	211° "	79.6° "
0 "	30. "	212° "	80. ° "

BOILING POINT OF WATER IN VACUUM.

Inches Vacuum.	Inches Barometer.	Temperature F.	Temperature R.
00	30	212°	80 °
11	19	190°	70 °
18	12	170°	61 °
22.5	7.5	150°	52.5°
25	5	135°	45.7°
27.5	2.5	112°	35.5°
28.5	1.5	92°	26.6°
29	1	72°	17.5°
29.5	0.5	52°	8.9°

THERMOMETERS.

"Measurement of Temperature and Heat." The degree of heat is measured by thermometers. The amount of heat is measured by the increase in temperature it is capable of producing in a certain quantity of water.

"Thermometers." The warmer a body is, the larger is its volume, and an increase in volume indicates a corresponding rise in temperature, a contraction of volume indicates a corresponding fall in temperature. This property is utilized for *measuring temperatures.*

Mercury or alcohol, enclosed in glass vessels, are the substances commonly used to measure the expansion produced by heat. Such instruments are called thermometers.

For description and testing of thermometers, see "The Brewers' Chemical Laboratory."

HEAT UNITS.

"Measurement of Heat, Heat Units." The amount of heat that will raise the temperature of one pound of water from 32° F. to 33° F. is called a heat unit, a therm, or a calory. To raise, for instance, the temperature of 5 pounds of water by 10° F. takes 5 × 10 or 50 heat units.

"Different Heat Units." Instead of taking for a unit the heat that can raise one pound of water by one degree Fahrenheit, a heat unit may be calculated upon a cubic foot of water, a barrel of water, or any quantity that may be convenient, and instead of Fahrenheit degrees, Reaumur or Celsius (Centigrade) may be used.

"For Calculations in the Brewery" it is often convenient to take as a heat unit the quantity of heat that will raise one barrel of water one degree Reaumur. As a barrel of water weighs 258.5 pounds and 1° R. = 2.25° F., this heat unit is 258.5 × 2.25 or 581.6 times larger than the ordinary heat unit. To raise ten barrels of water from 0° R. to 80° R., will take 10 × 80 or 800 such heat units, and if 10 barrels of water are cooled from 80° R. to 0° R., they give off 800 heat units.

As before stated, it requires as much heat to melt one pound of ice as to heat one pound of water from 32 to 174° F. To raise the temperature of one pound of water from 32° F. to 174° F. or by 174 — 32 = 142 degrees takes 1 × 142 heat units, that is, the "latent heat of melting ice" is 142 heat units.

Similarly, it takes as much heat to change one pound of water of 212° F. to one pound of steam of 212° F., as to raise 5.37 pounds of water from 32° F. to 212° F., or 5.37 × (212 — 32), or 5.37 × 180, or 972 heat units. The "latent heat of vaporization," therefore is 966 heat units.

SPECIFIC HEAT.

Equal weights of different substances require different amounts of heat to raise them to a given temperature. *Water requires* more heat than any other body, solid or *fluid, and is, therefore,* used as a unit. The figure that expresses

how much heat is required to raise the temperature of a certain weight of a body one degree as compared with that required to raise the temperature of an equal weight of water by one degree, is called the specific heat of the substance. The specific heat of barley malt, for instance, is 0.4, that is it takes only four-tenths of the heat which will raise the temperature of a certain weight of water one degree, to raise the temperature of an equal weight of malt one degree. To heat ten pounds of water from 40° F. to 100° F. takes 10×60, or 600, heat units; to heat 10 lbs. of malt from 40° F. to 100° F. takes only $10 \times 60 \times 0.4$, or 240, heat units.

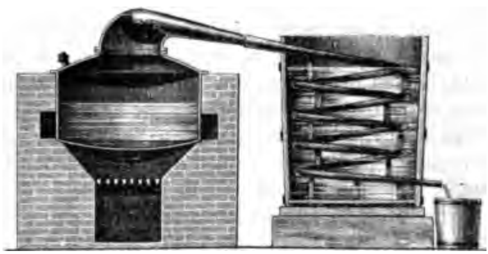


Fig. 4—Distilling Apparatus.

LIGHT.

Light is a form of energy which produces the effect of vision. Light, as well as sound, is transmitted through bodies in undulations or little waves. It is not in the molecules of a body, however, that light produces this wave-like movement in passing through such body, but in a substance which fills the spaces between the molecules as well as the space between the heavenly bodies. This substance is called ether, and is of excessive fineness, filling the whole universe and allowing the molecules of bodies to move in it with perfect freedom.

Light moves in this ether with a velocity of 186,000 miles per second.

A "ray of light" is a line along which light is moving.

A "beam of light" is a bundle of rays. Light moves in straight lines as long as the medium in which it moves is homogeneous, or of uniform density. If light enters into another medium of smaller or greater density, the ray of light is deflected, it no longer travels in the same direction.

If a straight stick is dipped partly into water, that part of the stick which is in the water will appear not to be in a continuous straight line with the part above the water; the stick appears to be broken. This is called refraction.

If a beam of light, coming through the air, falls upon the surface of another medium, for instance, glass or water, only part of the light will enter the glass or water, another part of the light being "reflected" back into the air.

The reflected ray of light forms an equal angle with the reflecting surface as the ray of light falling on the surface.

LENSES.

A piece of glass with one or both surfaces curved is called a lens. The ordinary or double-convex lens, is thicker in the middle than at the edges, and both surfaces are spherical. If such a lens is held in the sunlight, all the rays falling on its surface and passing through the glass, are broken or refracted and brought together in one point on the opposite side of the lens.

"Focus." If a piece of paper is held behind the lens and near to it, a circle of light smaller than the lens will become visible on the paper. If the paper is gradually moved further from the lens, the circle of light will grow smaller until it forms almost a point. This point is called the focus of the lens, and the distance from this point to the lens is called the focal length of the lens. The more curved the surfaces of the lens are, the nearer lies the focus to the lens. If another lens is held behind the first and parallel with it so that the sunlight passes through both lenses it will be seen that the focus is brought nearer to the lenses.

"Spherical Aberration." The rays that pass through a lens as described above do not all meet strictly in a point. The rays that fall on the lens near the edge are less acutely reflected and have their focus further from the lens than the rays that pass through the lens near the center. If the paper is held at the point where the central rays meet, the rays passing through near the edge will form a circle of light around this point.

"Diaphragms." To avoid this the rays near the edge are cut off by placing behind the lens a piece of blackened metal, with an opening in the center. Such a screen which only allows the central rays to pass through the lens is called a diaphragm.

"Images." If an object, for instance a burning candle, is held *in front of a lens,* at a distance a little greater than the focal

[redacted]

length, and a piece of paper is placed on the other side of the lens and moved to and from the lens, an inverted and magnified image of the candle will appear, and in a certain position this image will be sharply defined. The rays of light which are emitted from a single point of a burning candle, for instance, from the top of the flame, and fall on the lens, are all collected in one point behind the lens and there form an image of the corresponding point of the candle. Similarly, all points of the flame have their images in corresponding places behind the lens, and all these images jointly form an image of the whole flame.

MICROSCOPE.

"Magnifying Glasses." If a lens of the type above described is held between the eye and a small object, at a shorter distance from the object than the focal length, the image is larger than the object, but not inverted. Such a lens is called a simple microscope, or a magnifying glass.

"Compound Microscope." If we place the object as in the first instance, that is, a little further from the lens than the focal length, and thus produce an inverted and enlarged image of the object, and then view this image through another lens, as in the second instance, the enlarged image is magnified once more, producing a doubly enlarged and inverted image. A combination of two or more lenses in such a way is called a compound microscope.

COMPARATIVE ABSORBING OR RADIATING, AND REFLECTING PROPERTIES OF SOME SOLIDS.

Substance.	Absorbing or radiating power, proportion per cent.	Reflecting power, proportion per cent.
Water	100	0
Marble	93 to 98	7 to 2
Glass	90	10
Ice	85	15
Iron, cast, polished	25	75
Mercury	23	77
Iron, wrought, polished	23	77
Zinc	19	81
Steel, polished	17	83
Tin	15	85
Brass, dead polished	11	89
Brass, bright polished	7	93
Copper, hammered	7	93
Gold	5	95
Silver, polished	3	97

ELECTRICITY.

Electricity is the name given to the common cause of a large variety of phenomena, including apparent attractions and repulsions of matter, heat, luminous and magnetic effects, chemical decomposition, etc. Its nature is not well understood, there being no agreement whether it is a force or a fluid. Bodies that possess the power of producing electrical effects are said to be electrified, or in a state of electrification.

"Conductors" are substances through which electricity can pass easily. Such are metals, charcoal, acids, water, etc.

"Insulators" or "Non-Conductors" are bodies that offer great resistance to the passing of electricity. Such are: Silk, India rubber, porcelain, glass, sealing wax, vulcanite.

"Statical Electrification" or "Electricity Developed by Friction." Electricity can be produced by chemical action and by mechanical means. Electrification produced by rubbing glass with silk is called positive; that developed by rubbing sealing wax with flannel is called negative. The frictional electric machine consists of a circular plate of glass turning upon an axis between two cushions covered with amalgam. The friction between the glass plate and the amalgam produces electricity.

An insulated conductor, armed with points, discharges the plate as it turns, and thus becomes charged with electricity.

ELECTRIC CURRENT.

When two solid conductors are dipped into a fluid that acts unequally upon them, one of the conductors becomes charged with positive electricity, the other with negative. Thus pieces of zinc and carbon put into diluted sulphuric acid generate electrical force. The zinc is attacked by the acid and becomes negative, the carbon remains unaltered in the acid and becomes positive. If a metallic communication is made between the two plates, the elecricity is discharged. But as soon as the discharge has taken place, the two plates are immediately charged once more, and as this charging and discharging goes on without interruption the result is an electric current.

"Positive" and "Negative" Plates. That plate which is most *powerfully affected* by the liquid is called the positive plate; the *plate that remains* unaltered is called the negative plate.

"The Circuit." If the plates are united outside of the liquid by a metallic wire, this wire, the two plates and the fluid, that is, the path of the current, is called the circuit.

The "Positive Pole" is the free end of the wire connected with the negative plate.

The "Negative Pole" is the free end of the wire attached to the positive plate.

When the two poles are joined, the circuit is said to be "closed," when they are separated the circuit is "broken."

"Voltaic Cell." The plates, liquid and vessel constitute a voltaic cell.

"Voltaic Battery." Several cells joined form a voltaic battery.

The longer and finer the wire that connects the plates the greater is the "resistance" to the electric current.

MEASURES OF ELECTRICITY.

An "ohm" is the unit of resistance and is equal to the resistance of a column of mercury one square millimeter in cross-section and 106.3 centimeters long at 32° F.

A "volt" is the unit of electrical pressure, or electro-motive force, which is that force which compels electricity to move through a conductor in spite of its resistance.

An "ampere" is the unit of current strength or rate of flow through the conductor and consists of the current flowing in a unit of time (second) through a wire having a unit resistance (ohm) and between the two ends of which a unit difference of electrical pressure (volt) is maintained. (See also "Weights and Measures" and "Transmission of Power.")

MAGNETISM.

A "Magnet" is a body that has the power of attracting iron and steel and when freely suspended points north and south. The ends of a magnet are called the "poles." The force which causes such action is called magnetism.

"Electro-Magnet." If an electric current is sent through coils of wire wound around a soft iron bar such bar is magnetized, and is then called an electro-magnet. If a magnet is moved toward a closed coil of wire, an electric current is produced in the coil, and if the magnet is moved away from the coil a current of *opposite direction is* produced.

A "Magneto-Electric Machine" utilizes this principle for the purpose of inducing electric currents in wire coils by changing the relative positions of the wire coils and the magnets, alternately increasing and decreasing the distance.

The "Direct-Current Dynamo" is a device for generating an electric current. It consists of three principal parts: An "armature," made of coils of wire; an electro-magnet; and a "commutator" for giving the same direction to the alternating currents. The armature is a soft iron ring or cylinder carrying coils of insulated copper wire and arranged to rotate rapidly about the magnet. The soft iron in the coil increases the strength of the electric current.

SOUND.

Sound is that form of motion which affects the auditory nerve. It is produced by a succession of rapid vibrations in any elastic substance, solid, fluid or gaseous. These vibrations can be plainly seen in the strings of a piano or harp. Solid bodies and liquids conduct sound better than gases. Sound cannot be transmitted through a vacuum. Air is the principal carrier of sound; the velocity of sound through air is 1,090 feet per second.

Sound can be reflected and refracted in very much the same way as light. An "echo" is produced by sound waves reflected back to their source.

In the open air sound scatters in all directions, and its intensity diminishes rapidly with the distance. If by some means the vibrations are made to move in one direction or confined within a narrow space, the sound can be heard farther. (Speaking tubes and speaking trumpets.)

TELEPHONE.

The telephone is an instrument for transmitting sound over a long distance. The sound vibrations produced when a person speaks into the mouthpiece of the instrument cause a thin iron plate to vibrate, thereby producing electric currents in an electro-magnet. These electric currents are sent by a metallic wire to a distant place, and received in a similar instrument, causing the iron plate to vibrate in exactly the same manner as the first. These vibrations are imparted to the air and thus reproduce the sound.

PHONOGRAPH.

The phonograph or talking machine consists in its main feature of a revolving mandrel, covered with a wax cylinder and driven by a clock-work or electric motor.

Upon this wax cylinder is placed a moveable recorder, consisting of a housing containing a thin glass diaphragm. To this diaphragm is attached a sharp chisel-shaped peg or pin on one side, where it rests upon the cylinder, and a horn or sound receiver to the other side of the housing. As a sound of greater or lesser intensity enters this horn it causes the diaphragm to vibrate with corresponding intensity and to cut indentations into the surface of the wax cylinder. By replacing the recorder with a reproducer (which is similar to it in construction, except that the cutting pin is replaced by a rounded blunt pin), the diaphragm, as its pin sinks into the depressions of different depths in the wax, is caused to vibrate in the same manner as did the diaphragm of the recorder, thereby reproducing the original sound.

MECHANICS.

Mechanics treat of the movements of bodies, their causes and effects.

"Motion" is a change of position.

VELOCITY.

"Velocity" is rate of motion. Velocity is either "uniform" or "variable." The velocity of a body at any instant is the distance it would pass over in the next unit of time without any influence from outside.

The distance traversed in a given time by a body moving with uniform velocity is equal to the velocity multiplied by the number of time units. For instance, if a train moves with a speed of 40 miles an hour, the distance traversed in three hours is equal to 3×40, or 120 miles, that is, distance $= 3 \times 40 = 120$.

If we call the distance l, the velocity v, and the time (expressed in the units of time) t, we have $l = v\,t$. From this formula it follows that

$$v = \frac{l}{t} \text{ and } t = \frac{l}{v}$$

that is, velocity is equal to distance divided by the time, and the time is equal to distance divided by the velocity. If the train moves 120 miles in four hours, the velocity is equal to $\frac{120}{4}$, or 30 miles per hour; and if the train moves 120 miles at a velocity of 40 miles per hour, the time needed to traverse the distance is $\frac{120}{40}$, or three hours.

If two of the three quantities, distance, time and velocity, are given, the third can always be found.

ACCELERATION.

Acceleration is the change of velocity per unit of time and may be either "positive" or "negative." If the velocity increases, *acceleration is positive*; if the velocity diminishes, it is negative.

"Accelerated Movement." If a body has a uniformly accelerated movement and starts from rest, the velocity, after a certain time, is equal to the acceleration multiplied by the time. If, f. i., a body begins to move, and its speed increases seven feet per second, the velocity will, after three seconds, be 3×7 or 21 feet. Representing the acceleration by a, the time by t, and the velocity by v,

$$v = a\,t.$$

The distance traversed is equal to one-half of the acceleration multiplied by the square of the time, or, calling the distance l,

$$l = \tfrac{1}{2}\,a\,t^2.$$

GRAVITATION.

The best known example of a uniformly accelerated motion is the motion of a freely falling body. A body dropped from a place above the surface of the earth falls in a straight line and in the direction of the center of the earth.

When we speak of the "weight" of a body we mean that force by which the earth attracts the body, and this force constitutes "gravity," or the "attraction of gravitation."

A heavy body and a light body, falling freely, will fall to the ground in the same time, if they both are dropped from the same height. In a vacuum, where the resistance of the air is removed, a feather and a stone will fall with equal velocity. If a body starts from rest and falls freely, it will, at the end of the first second, have a speed of 32.16 feet, that is, the acceleration in this case is 32.16 feet. This quantity is generally denoted by the letter g. It is different in different parts of the earth. At the equator g is 32.09 feet, at the pole 32.25 feet. Accordingly the velocity of a freely falling body

$$v = g\,t,$$

that is, at the end of two seconds the velocity is 2×32.16, or $2\,g$, after three seconds 3×32.16, or $3\,g$, etc.

The space traversed

$$s = \tfrac{1}{2}\,g\,t^2.$$

Hence in the first second the space is $\tfrac{1}{2}\,g \times 1^2 = \tfrac{1}{2} \times 32.16 =$ 16.08 feet; at the end of two seconds it is $\tfrac{1}{2}\,g \times 2^2$, after three seconds $\tfrac{1}{2}\,g\,3^2$, etc. The space traversed is equal to 16.08 feet multiplied by the square of the number of seconds.

Example 1.—How many feet does a body, starting from rest, *drop in five seconds?*

Solution.—$s = 16.08 \times 5^2 = 16.08 \times 25 = 402$ feet.

Example 2.—How much time would a falling body, starting from rest, require to drop one mile?

Solution.—1 mile = 5.280 feet; $s = \frac{1}{2} g t^2$; $5{,}280 = 16.08 \times t^2$.

$$t^2 = \frac{5280}{16.08} = 328;$$

$$t = \sqrt{328} = 18 \text{ seconds}$$

LAWS OF MOTION.

"Force" is that which changes, or tends to change, the state of rest or motion of a body. A given force produces the same effect, whether the body on which it acts is in motion or at rest; whether it is acted on by that force alone or by other forces at the same time.

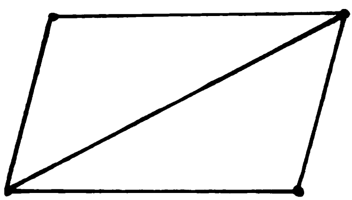


Fig. 1—Representation of Forces.

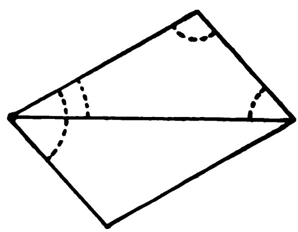


Fig. 2—Composition of Motion.

In treating of forces, there are three things to be considered: The "point of application," or the point at which the force acts.

The "direction," or the line along which it tends to move the point of application.

The "magnitude" of a force when compared with a given standard.

REPRESENTATION OF FORCES.

A force may be represented by a straight line, one end of which determines the point of application, the direction of the line indicating the direction of the force, and the length of the line determining the magnitude of the force.

COMPOSITION OF MOTION.

A motion may be the resultant of two or more component motions.

When two motions have the same direction, the magnitude of

the resultant motion is the sum of the magnitudes of the components, and the direction will be unchanged.

When two motions have opposite directions, the magnitude of the resultant motion will be the difference of the magnitudes of the components, and the direction will be that of the greater component.

When two component motions have different directions, the resultant motion is represented in magnitude and direction by the diagonal of the parallelogram constructed over the two component motions, as sides of the parallelogram. Thus let the two forces be represented by the two lines *AB* and *AC*. Draw *BD* and *CD* to complete the parallelogram. The diagonal *AD* then represents the direction and magnitude of the resultant motion.

MOMENTUM.

If a force acts upon a body the result of this action depends upon the mass of the body and its velocity. The product of the mass and the velocity is called momentum.

MEASUREMENT OF FORCES.

In order to compare forces we must have a unit of force by which they can be measured. There are two kinds of units of force.

1. The "gravity unit," which is the weight of any standard unit of mass, as f. i., the pound.

2. The "absolute unit," which is the force that acting for a unit of time upon a unit of mass will produce a unit of acceleration. Such a unit is, f. i., the foot-pound-second unit of force which, acting on one pound of matter for one second, will produce an acceleration of one foot per second. It is called a "poundal."

WORK AND ENERGY.

When a force causes motion of a body through space, it is said to do "work" on that body.

"Foot-pound." The unit of work is the amount of work required to raise one pound one foot against the force of gravity, and is called a foot-pound. Three pounds raised 10 feet, or 10 pounds raised three feet, represent 30 foot-pounds. Where the metric system is used the unit of work is the meter-kilogram.

"Horse-power" is the power to do 550 foot-pounds of work per second, or 33,000 foot-pounds per minute.

"Energy" is the power of doing work. A falling stone, running water, etc., have energy. It is measured in foot-pounds, the same as work.

SIMPLE MACHINES.

A machine is an instrument for the transference of energy.

The "power" of a machine is the force that acts upon one part of a machine. Power is the time rate of doing work.

The "weight" is the force exerted by another part of the machine upon some external resistance.

All machines waste more or less of the energy exerted in overcoming resistances of friction, air, etc. The "efficiency" of a machine is the ratio of the useful work done by the machine to the total work done ~~on~~ by the machine.

"Friction" is the resistance that a moving body meets from the surface on which it moves. Friction may be rolling or sliding. (See "Elements of Machinery.")

THE MECHANICS OF LIQUIDS.

Liquids are practically incompressible, even very heavy pressure fails to reduce their volume to any appreciable extent. They are also perfectly elastic, that is, when the pressure ceases, they regain their former volume fully.

If a liquid is inclosed in a vessel and a pressure is exerted upon a part of its surface, that pressure is transmitted in all directions, and acts with equal force upon any part of the total surface equal in extent to the part on which the pressure is originally exerted.

This law finds an application in the "hydraulic press," which consists of two cylinders of unequal diameters, communicating with each other and filled with water. A pressure downward on the water in the narrow cylinder produces a pressure upward in the wide cylinder, as many times greater as the sectional area of the narrow cylinder is contained in that of the wide cylinder. (See page 149.)

If a liquid is contained in a vessel, the pressure on the bottom is independent of the shape of the vessel. and depends only on the depth of the liquid and the area of the bottom. If, f. i., two vessels filled with water have equal height and bottom, and one has *the shape of straight* cylinder, the other that of a cone, the pres-

sure on the bottom is equal, although the cylinder contains three times as much water as the cone-shaped vessel.

ARCHIMEDES' PRINCIPLE.

If a substance is immersed in water, or any other liquid, it displaces its own volume of water. At the same time the apparent weight of the body in the liquid is less than its true weight in air. This is generally spoken of as a "loss of weight." This "loss of weight" is equal to the weight of the displaced fluid, a truth discovered by Archimedes. A cubic foot of stone weighs about 169 lbs., a cubic foot of water 62.5. If the stone is suspended in water, it weighs only 106.5 lbs., or 169 — 62.5, its weight in air less the weight of one cubic foot of water.

If a body floats in a liquid it sinks until the displaced liquid weighs as much as the floating body.

BREWERY HYDRAULICS.

With respect to the occurrence of hydraulic force in the brewery a few propositions may be laid down to indicate the principles to be considered. The calculations are, in most cases, too complicated for the brewer to perform in the course of his work, and may be left to the architect, engineer, tank manufacturer, coppersmith, refrigerator man and others who supply vessels and pipes.

The "normal pressure" on the "base of a vessel" filled with water is equal to the weight of a cylinder of water whose base is the base of the vessel, and whose height is the depth of water. This applies to other liquids as well.

The "normal pressure" on the "interior surface" of a vessel filled with water is greater than the weight of the water, for the weight acts only vertically, while the normal pressures are exerted in all directions.

If an orifice is opened in the bottom or side of a vessel, the "theoretical velocity" of flow at the orifice is the same as that acquired by a body falling freely in a vacuum through a height equal to the head of water on the orifice. This theoretical velocity is found in feet per second by multiplying the square root of the head or vertical depth in feet by the constant number 8.03, or multiplying the head itself in feet by 64.4 and taking the square root of the product. In practice, the figures 8 and 64 are near enough.

The "theoretical" as well as the "actual discharge," or the quantity in cubic feet flowing out per second, is equal to the product of the velocity (theoretical or actual, respectively) in feet per second, and the area of the opening in square feet.

These theoretical laws apply to all fluids, whatever their specific gravity.

In flowing out through an orifice, the jet of water is contracted, forming the so-called "contracted vein." Hence, in calculating velocity and discharge by the above rule, the result must be multiplied by the "coefficient of discharge," representing this contraction, which has been determined in many cases approximately by experiment. In emptying a tank, the head decreases as the level of the liquid falls. The form of the orifice also should be considered, a "standard orifice," whose edges are straight, causing a greater contraction of the jet and reducing the theoretic outflow. For this reason rounded edges are often used.

TIME OF DISCHARGE OF PRISMATIC VESSEL.

A formula for calculating the theoretic time of discharge of a prismatic vessel (cylindrical or square tank, etc.) through an orifice while the vessel receives no fresh inflow of liquid, is as follows:

$$t = \frac{2A}{a\sqrt{2g}} \times (\sqrt{H} - \sqrt{h})$$

t is the time of discharge in seconds, H the head on the orifice at a given instant in feet, h the head t seconds later, A the area of the uniform or mean cross-section of the vessel in square feet, a the area of the orifice in square feet. To compute the actual time requires the multiplication of the result by the coefficient of discharge, making the calculation much more complicated. Roughly, however, a standard orifice, that is, one with a straight edge, gives about 61 per cent. of the theoretic discharge. By the attachment of a tube outside, this may be increased to 82 per cent, such a tube creating a partial vacuum near the orifice and increasing the outflow. The result should therefore be multiplied by 0.61, or 0.82, if a pipe is attached, for a standard orifice, or by the coefficient of discharge for other orifices. For practical purposes in the brewery the formula is sufficient, as the standard edge is generally employed.

The question will most frequently occur in the form of requiring the time it will take for a vessel to empty itself by running

[redacted]

out through an orifice in the side near the bottom. In that case the above formula can be used, h being omitted inasmuch as the head at the end of the period, that is, when the vessel is empty, is $= 0$. The formula would then be for the time required to empty a vessel:

$$t = \frac{2A\sqrt{H}}{a\sqrt{2g}}$$

g being the constant value 32.16 for the acceleration of a freely falling body.

It should be borne in mind that the velocity of the outflow depends on the head, not on the surface or volume of fluid. A tall, slender tank, therefore, will run dry quicker than a shallow one of equal capacity. Where a steady flow is of greater importance than great velocity, as may often be the case with beer to avoid foaming, a shallow vessel may be preferable. The capacity or contents of a tank in barrels and the size of outlet are not alone to be considered in calculating the time of discharge.

It is also to be remembered that the above formula gives the "theoretical" time. To get the "actual" time, take 61 per cent of the theoretical, where the discharge is free into the air, or 82 per cent where it is through a pipe of even bore with the orifice.

TIME FOR EMPTYING A TANK.

The practical working formula for the time required to empty a tank will be:

$$t = \frac{2A\sqrt{H}}{a\sqrt{2g}} \times 0.82$$

Example.—The fluid in an upright cylindrical tank stands 5 feet high, and has 8 feet diameter. How long will it take to run off through a standard tap hole of 1.5 inch diameter, opening into a straight, horizontal pipe of suitable width?

Solution: $A = (\frac{8}{2})^2 \times 3.1416;\ H = 5;$

$$a = \left(\frac{1.5}{12}\right)^2 \times 0.7854;\ g = 32.16.$$

$$t = \frac{2 \times 50\ 2656 \times 2.237}{0.01227 \times 8.02} = 2285 \text{ seconds.}$$

Taking 82 per cent of this number for the actual as against the theoretical value for emptying through a pipe, gives 2784.15 seconds, or

Answer.—46 minutes 24 seconds.

These are values for velocity and discharge where the fluid flows out into the open air. Where the discharge is under water, the velocity and discharge are about 0.013 less.

FLOW OF PIPES.

In a pipe the discharge is reduced from various causes, the principal ones being friction, contractions or sudden enlargements, sharp curves, etc. In a general way, it may be said that:

1. The loss in friction is proportional to the length of the pipe;
2. It increases nearly as the square of the velocity.
3. It decreases as the diameter of the pipe increases.
4. It increases with the roughness of the interior surface.
5. It is independent of the pressure of the water.

To compute the diameter of a straight, horizontal pipe of uniform size for a given discharge and length, an approximate formula may be given, which may be used in calculating the size of pipe required to discharge a vessel in a certain time.

$$d = \sqrt[5]{\left[(1 + m)d + fl\right] \times \frac{16q^2}{2gh \times 3.14^2}}$$

The larger the bore of the pipe, the less the loss by friction.

d is the required diameter; m is 0.93 where the pipe projects inward, 0.49 for a standard (straight edge) orifice and no inward projecting pipe, and 0 for a perfect rounded orifice and no projecting pipe; f is the friction factor for which a rough mean value often used is 0.02; l is the length of the pipe in feet; q is the discharge from the vessel in cubic feet per second; h is the head of liquid in the vessel to be discharged, in feet.

Practical working formulas are given in connection with the next following table.

This table gives the head of fluid consumed by friction in pipes one yard long and from 1—4 inches in diameter; it thus indicates the head of water required to produce a given flow per minute. Various rules enable us to use this table for the purpose of calculating lengths and diameters of pipes, discharge in gallons, and head in feet for given quantities.

Discharge Galls per min	Diameter of the Pipe, in Inches.						
	1	1¼	2	2½	3	3½	4
	Head of Water, in Feet.						
1	0.0011	0.00054	0,00012	0.000042	0.000016	0.0000078	0.000004
2	0.0164	0.00216	0.00051	0.000168	0.000067	0.0000313	0.000016
3	0.0370	0.00487	0.00115	0.000379	0.000152	0.0000705	0.000036
4	0.0658	0.00867	0.00205	0.000674	0.000271	0.0001250	0.000064
5	0.1028	0.01354	0.00321	0.001053	0.000423	0.000195	0.000100
6	0.1481	0.01950	0.00463	0.001517	0.000609	0.000282	0.000111
7	0.2016	0.02655	0.00330	0.002064	0,000830	0.000383	0.000196
8	0.2633	0.03468	0.00823	0.002696	0.001084	0.000501	0.000257
9	0.3333	0.04389	0.01041	0.003413	0.001372	0.000634	0.000325
10	0.4110	0.05410	0.01286	0.004210	0.001690	0.000783	0.000401
20	1.64	0.21670	0.05140	0.016850	0,006770	0.00313	0.001600
30	3.70	0.48770	0.115	0.037920	0.0152	0.00707	0.003610
40	6.58	0.86700	0.205	0.067420	0.0271	0.01253	0.006430
50	10.28	1.35	0.321	0.1053	0.0423	0.01958	0.010040
60	14.81	1.95	0.463	0.1517	0.0609	0.02820	0.014460
70	20.16	2.65	0.630	0.2064	0.0830	0.03839	0.019690
80	26.33	3.46	0.823	0.2696	0.1084	0.05014	0.025720
90	33.33	4.38	1.041	0.3413	0.1372	0.06346	0.032550
100	41.1	5.4	1.28	0.421	0.169	0.078	0.0101
110	49.7	6.5	1.55	0.509	0.205	0.094	0.0486
120	59.2	7.8	1.85	0.606	0.243	0.112	0.0578
130	69.5	9.1	2.17	0.712	0.286	0.132	0.0679
140	80.6	10.6	2.52	0.825	0.332	0.153	0.0788
150	92.5	12.1	2.89	0.948	0.381	0.176	0.0904
160	105.3	13.8	3.29	1.078	0.433	0.200	0.1028
170	118.9	15.6	3.71	1.217	0.485	0.226	0.1161
180	133.3	17.5	4.16	1.365	0.549	0.253	0.1312
190	148.5	19.5	4.64	1.521	0.611	0.282	0.1450
200	164.6	21.6	5.14	1.685	0.677	0.313	0.1607
210	181.4	23.8	5.67	1.858	0.747	0.345	0.1772
220	199.1	26.2	6.22	2.039	0.819	0.379	0.1945
230	217.6	28.6	6.80	2.229	0.896	0.414	0.2126
240	237.0	31.2	7.40	2.427	0.975	0.451	0.2311
250	257.1	33.8	8.03	2.633	1.058	0.489	0.2511
260	278.1	36.6	8.69	2.848	1.145	0.529	0.2716
270	299.9	39.5	9.37	3.071	1.234	0.571	0.2929
280	322.5	42.4	10.08	3.303	1.328	0.614	0.3150
290	346.0	45.5	10.81	3.544	1.424	0.658	0.3379
300	370.3	48.7	11.58	3.792	1.524	0.705	0.3617
310	395.4	52.0	12.35	4.049	1.627	0.752	0.3162
320	421.3	55.5	13.16	4.215	1.734	0.802	0.4115
330	448.1	59.0	14.00	4.583	1.844	0.853	0.4376
340	475.6	62.6	14.87	4.871	1.958	0.905	0.4645
350	504.0	66.3	15.75	5.162	2.075	0.959	0.4923
360	533.3	70.2	16.66	5.461	2.196	1.015	0.5248
370	563.3	74.1	17.60	5.769	2.336	1.072	0.5502
380	594.2	78.2	18.57	6.085	2.446	1.131	0.5803
390	625.8	82.4	19.56	6.408	2.576	1.191	0.6112
400	659.4	86.7	20.57	6.742	2.710	1.253	0.6430
410	691.7	91.0	21.61	7.083	2.847	1.317	0.6755
420	725.8	95.5	22.68	7.433	2.988	1.382	0.7089
430	760.8	100.1	23.80	7.790	3.130	1.448	0.7430
440	796.6	104.9	24.80	8.150	3.270	1.516	0.7780
450	833.2	109.7	26.00	8.530	3.430	1.586	0.8130
460	870.7	114.6	27.20	8.910	3.580	1.657	0.8500
470	909.0	119.7	28.40	9.300	3.740	1.730	0.8870
480	948.0	124.8	29.60	9.700	3.900	1.805	0.9250
490	988.0	130.1	30.80	10.110	4.060	1.881	0.9640
500	1028.7	135.4	32.10	10.530	4.230	1.958	1.0040

To find the head of fluid for a given diameter and length of pipe and discharge in gallons per minute: Find, in above table, head for length of one yard opposite discharge in gallons; multiply by given length in yards.

Example.—Find head necessary to deliver 100 gallons per minute by a pipe 3 in. diameter and 200 yards long.

Solution.— $0.169 \times 200 = 33.8$ feet head.

To find the diameter of a pipe for a given head, length of pipe, and discharge, divide head in feet by length of pipe in yards and find in the table opposite the figure for the discharge, the number nearest the quotient; take the diameter from the head of the column in which such number stands.

Example.—What diameter should a pipe have to deliver 100 gallons a minute through a pipe 200 yards long under a head of 34 feet?

Solution.— $34 : 200 = 0.17$;
number nearest this quotient opposite 100 gallons discharge is 0.169; diameter at head of column in which this number stands is 3, which is the required diameter.

To find the discharge in gallons for a given head, length of pipe and diameter of same: Divide head of fluid in feet by length in yards; find the nearest number in the table under the given diameter and read off the number of gallons in the first column of the table.

Example.—How many gallons of water will a 3-inch pipe of 200 yards under a head of 34 feet deliver per minute?

Solution.— $34 : 200 = 0.17$.
nearest number under diameter 3 inches is 0.169; corresponding number in first column, 100, which is the required number of gallons.

To find the length of pipe for a given head, discharge, and diameter of pipe, divide the given head by the head for one yard as given in the table for the given diameter and discharge; the quotient is the required length.

Example.—How long should a 3-inch pipe be to deliver 100 gallons a minute under a head of 34 feet?

Solution.— $34 : 0.169 = 201$,
which is the required length.

APPROXIMATE FLOW OF PIPES.

A simple way to calculate the approximate discharge of a pipe *is by means of Prony's* formula. Multiply the head in inches

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by the diameter of the pipe in inches, and divide by the length of the pipe in inches $\frac{h \times d}{e}$. Then find the number nearest the quotient thus obtained in the first column of the subjoined table, and the required discharge will appear in gallons per minute opposite this figure under the diameter of the pipe.

APPROXIMATE FLOW OF PIPES (PRONY'S FORMULA).

$\frac{H \times d}{L}$	Velocity in feet per second.	Diameter of the Pipe, in Inches.								
		1	1¼	2	2½	3	3½	4	5	6
		Gallons Discharged per Minute.								
0.00002402	0.025	0.0511	0.1150	0.2045	0.3196	0.4602	0.626	0.818	1.278	1.841
0.00005437	0.05	0.1022	0.2301	0.4091	0.6392	0.9204	1.252	1.636	2.556	3.682
0.00009108	0.075	0.1534	0.3450	0.6136	0.9588	1.381	1.878	2.454	3.834	5.523
0.0001341	0.100	0.2045	0.4602	0.8182	1.278	1.841	2.504	3.273	5.113	7.363
0.0001836	0.125	0.2556	0.5750	1.023	1.598	2.301	3.130	4.090	6.390	9.205
0.0002394	0.15	0.3057	0.6900	1.227	1.917	2.761	3.756	4.908	7.668	11.05
0.0003016	0.175	0.3578	0.8053	1.432	2.237	3.221	4.382	5.728	8.947	12.83
0.0003702	0.2	0.4090	0.9204	1.636	2.557	3.682	5.008	6.546	10.23	14.73
0.0004452	0.225	0.4601	1.035	1.841	2.876	4.142	5.634	7.363	11.50	16.57
0.0005266	0.25	0.5112	1.150	2.045	3.196	4.602	6.260	8.160	12.78	18.41
0.0006140	0.275	0.5624	1.265	2.250	3.515	5.062	6.886	9.000	14.06	20.25
0.0007080	0.3	0.6135	1.381	2.454	3.835	5.522	7.512	9.819	15.34	22.00
0.0008087	0.325	0.6648	1.496	2.659	4.154	5.982	8.138	10.64	16.62	23.93
0.0009154	0.35	0.7157	1.611	2.864	4.474	6.443	8.764	11.46	17.89	25.77
0.0010286	0.375	0.7669	1.726	3.068	4.794	6.903	9.390	12.27	19.17	27.61
0.0011480	0.4	0.8180	1.841	3.273	5.113	7.363	10.02	13.09	20.45	29.45
0.001274	0.425	0.8691	1.955	3.477	5.433	7.823	10.64	13.91	21.78	31.29
0.001406	0.45	0.9202	2.071	3.682	5.757	8.284	11.27	14.73	23.01	33.13
0.001545	0.475	0.9713	2.186	3.886	6.077	8.744	11.89	15.55	24.29	34.97
0.001690	0.5	1.023	2.301	4.091	6.392	9.204	12.52	16.37	25.57	36.82
0.002	0.55	1.125	2.531	4.500	7.031	10.12	13.77	18.00	28.12	40.50
0.00233	0.6	1.227	2.761	4.909	7.670	11.04	15.02	19.64	30.68	44.18
0.002693	0.65	1.329	2.901	5.318	8.309	11.96	16.28	21.27	33.23	47.86
0.003079	0.7	1.431	3.221	5.727	8.948	12.88	17.53	22.91	35.79	51.54
0.003490	0.75	1.533	3.450	6.136	9.588	13.81	18.78	24.54	38.34	55.23
0.003926	0.8	1.636	3.682	6.544	10.23	14.73	20.03	26.18	40.90	58.90
0.004388	0.85	1.738	3.912	6.954	10.86	15.65	21.29	27.82	43.46	62.59
0.004876	0.9	1.841	4.142	7.363	11.51	16.57	22.53	29.46	46.02	66.27
0.005928	1.0	2.045	4.602	8.182	12.78	18.41	25.04	32.73	51.13	73.63
0.00648	1.05	2.147	4.832	8.591	13.42	19.33	26.29	34.37	53.69	77.31
0.00708	1.1	2.249	5.062	9.000	14.06	20.25	27.54	36.00	56.24	80.99
0.007691	1.15	2.351	5.292	9.409	14.70	21.15	28.80	37.64	58.80	84.67
0.008338	1.2	2.454	5.522	9.818	15.34	22.09	30.05	39.28	61.36	88.36
0.009	1.25	2.556	5.753	10.23	15.96	23.01	31.30	40.91	63.91	92.04

UPWARD OR DOWNWARD FLOW OF PIPES.

The formulas given are for horizontal pipes or hose. Where there is a difference in height between the point of entry of the *pipe and the point* of discharge, the formula remains the same,

but the value of the head will be different. The head for a horizontal pipe is the height of the surface of the liquid above the point of entry into the pipe, which point is on a level with the point of discharge.

Where the pipe falls or rises from the point of entry to the point of discharge or nozzle the head on the fluid is different. The head is always equal to the vertical difference between the surface of the fluid and the point of discharge. Where a pipe falls, after leaving the point of entry, the head will increase; where it rises, the head will diminish.

Thus, where a fluid is run from a tank on one floor to a vessel on a floor below, the total head is the difference in altitude between the surface of the fluid in the upper tank and the point of discharge in the lower, so that the head is largely increased over that of an horizontal pipe or hose. Where, on the other hand, the fluid is discharged at a point higher than the point of entry into the pipe, the head will be diminished as against that of an horizontal pipe.

Example 1.—What will be the discharge of a 3-inch pipe carrying a fluid from a tank in which it stands 8 feet high, and being emptied into a vessel 8 feet high, standing on a floor 20 feet below the first tank, both tanks standing on the respective floors without feet or other supports raising them above the level floors. The first tank stands at one end of the floor, the second at the opposite end of the one below, giving the pipe a length of 210 feet. The fluid in the supply tank is kept at a uniform height by a constant inflow of fresh fluid.

Solution.—Assuming the water to be delivered at the top of the lower vessel, the head of the fluid will be the height of the upper tank (8 ft.) plus difference in altitude of floors, less height of lower vessel (20 — 8 ft.).

$$8 + 20 - 8 = 20 \text{ ft.}$$

Reduce length of pipe in feet to yards: $210:3 = 70$. Inserting these values according to above rule for finding the discharge in gallons for a given head, length of pipe and diameter, gives $20:70 = 0.29$: nearest number in table under diameter 3 inches 0.286; corresponding number in first column 130.

Answer.—Required discharge in gallons per minute $= 130$.

The capacity of the tank to be filled being known, this affords *a simple means of* computing the time that will be required to *fill it from the supply* tank.

RULES FOR LAYING PIPES OR HOSE.

The shorter the pipe, the greater the discharge; hence unnecessary length of pipe is to be avoided where time is of any moment.

Angles and curves are to be avoided for the same reason, as they materially interfere with the flow of fluid through pipes. Hence the hose, where such is used, should be of just the requisite length to avoid a waste of time or pressure. In the case of wort or beer this is all the more important since the viscosity of the material augments the friction in the pipe.

Sharp angles are to be avoided entirely in pipes and hose, as well as contractions and enlargements of bore. Where curves or elbows cannot be avoided they should be well rounded and of large radius. In that case they offer so little resistance to the fluid that no account need be taken of them in computing time of discharge. By radius is meant the radius of the arc formed by the axis or central line of the bend. This should not be less than five times the diameter of the pipe.

Where the respective values can be ascertained, the following formulæ can be used:

t = value given in table, next below, for each diameter.

h = height of column of water in feet $\frac{h}{2} = p$

p = pressure in lbs per square inch.

v = velocity in feet per second.

l = length of pipe in feet.

Q = number of cubic feet discharged per minute.

G = number of gallons discharged per minute.

$x = \frac{l}{h}$ = co-efficient of inclination.

To find G; given d, h, l

$$G = \frac{t}{\sqrt{x}} \times 7.5$$

To find Q; given d, h, l

$$Q = \frac{t}{\sqrt{x}}$$

To find d; given l, h, Q.

$t = Q\sqrt{x}$, find value for d opposite t in table

To find h; given l, Q, d

$$h = \frac{1}{\left(\frac{t}{Q}\right)^2}$$

To find p; given l, Q, d

$$p = \frac{l}{2\left(\frac{t}{Q}\right)^2}$$

To find v; given Q, d

$$v = \frac{10\,Q}{d^2\,\pi}$$

To find v; given l, d, h

$$v = 41.6\,\frac{\sqrt{h\,12\,d}}{l}$$

To find x; given Q, d, l

$$x = \left(\frac{v}{2356}\right)^2 \frac{1}{d^5}\,d;\ (d \text{ in feet}).$$

DISCHARGE OF WATER IN PIPES.

Diam.	t Tub. No.	Diam.	t Tub. No.	Diam.	t Tub. No.	Diam.	t Tub. No.	Diam.	t Tub. No.
Ft. In.		Ft. In.		Ft. In.		Ft. In.		Ft. In.	
1	4.71	9	1147.6	1 11	11963	3 1	39329	4 9	115854
1.25	8.48	10	1493.5	2	13328	3 2	42040	5	131703
1.5	13.02	11	1694 9	2 1	14758	3 3	44863	5 3	148791
1.75	19.15	1	2356	2 2	16278	3 4	47794	5 6	167139
2	26.69	1 1	2876.7	2 3	17889	3 5	50834	5 9	186786
2.5	46.67	1 2	3473.3	2 4	19592	3 6	53995	6	207754
3	73.5	1 3	4115.9	2 5	21390	3 7	57265	6 6	253781
3.5	108.14	1 4	4856 9	2 6	23282	3 8	60648	7	305437
4	151.02	1 5	5628.5	2 7	25270	3 9	64156	7 6	362395
4.5	194.84	1 6	6393 1	2 8	27358	3 10	67782	8	426481
5	263.87	1 7	7453	2 9	29547	3 11	71526	8 6	496275
6	416.54	1 8	8449	2 10	31834	4	75392	9	572508
7	612.32	1 9	9544	2 11	34228	4 3	87730	9 6	655369
8	854.99	1 10	10722	3	36725	4 6	101207	10	748068

THE MECHANICS OF GASES.

Elastic Force of Gases.—Gases are in the highest degree elastic. The volume of a gas depends upon the pressure exerted upon it. If the pressure is increased two, three or four times, the volume decreases at the same rate, that is, the gas that under a certain pressure occupies one cubic foot will, when the pressure increases four times, occupy one-fourth of one cubic foot. As soon as the pressure is released the gas will resume the original volume.

Again, a volume of air, or another gas, which, under ordinary circumstances, fills one cubic foot, can be made to expand to any volume by the release of the pressure upon it.

PUMPS.

On these principles is based the construction of the "air-pump," which is an instrument for removing a gas from a closed vessel.

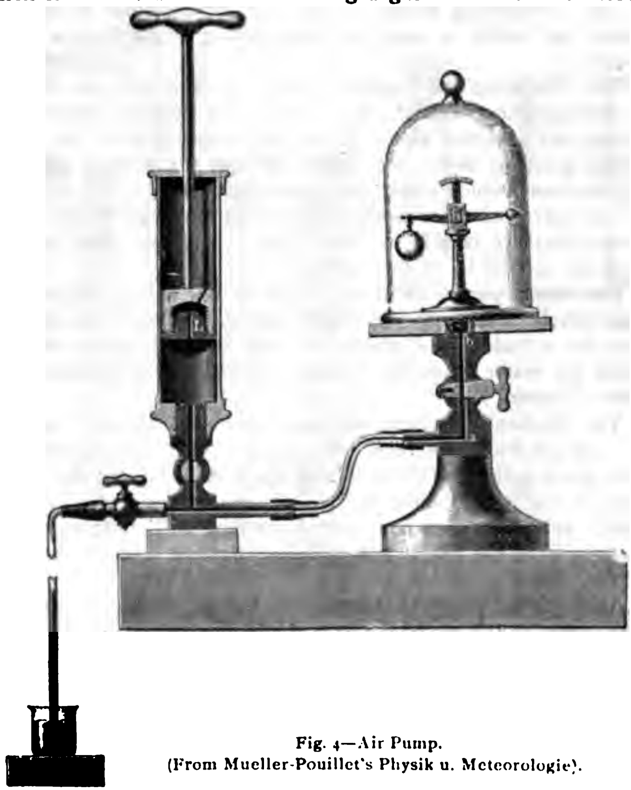


Fig. 4—Air Pump.
(From Mueller-Pouillet's Physik u. Meteorologie).

The air-pump consists essentially of a metallic cylinder, in which moves a tightly-fitting piston. The bottom of the cylinder communicates with the vessel to be exhausted, and has a valve *opening upward.* A similar valve is fitted to the piston. When th

piston is raised from the bottom of the cylinder, the air in the vessel to be exhausted expands and fills the vacuum formed under the piston. When the piston descends, the valve in the bottom of the cylinder closes, and the air in the cylinder escapes through the valve in the piston. In this manner a cylinder full of air is removed at every stroke of the pump.

The "condensing pump" is an instrument similar to the air-pump, but which is used for compressing a gas into a closed vessel.

The "lift pump" or "suction pump" raises water with the help of atmospheric pressure. It consists of a cylinder, piston, two valves and a suction pipe. When the piston is raised the atmospheric pressure forces the water through the suction pipe into the vacuum formed under the ascending piston.

The water can theoretically be lifted only as high as the atmospheric pressure is able to lift it, that is, 34 feet. The practical limit by suction is, in fact, 28 feet.

The "force pump" is used for lifting water to a higher level than can be done with the suction pump. Atmospheric pressure fills the cylinder, and steam or some other power is used to force the water from the cylinder through the discharge pipes. (See "Power.")

The "siphon" is a bent tube with unequal arms used to transfer liquids from one level over an elevation to a lower level. It is set in action by filling it with the liquid, dipping the shorter arm in the liquid, while the longer arm is brought to a lower level. When the ends are opened the flow will continue as long as the end of the longer arm is lower than the level of the liquid in the vessel.

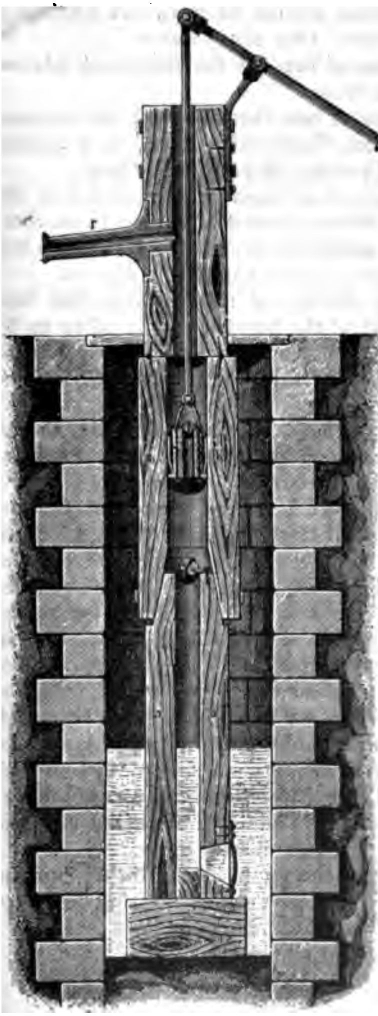
Atmospheric pressure keeps the siphon filled, the surplus weight of the column of liquid in the longer arm makes the liquid run out of the tube.

THERMODYNAMICS.

Thermodynamics treat on the relation between heat and work.

Heat can be changed into motion, and motion into heat. The mechanical effect of steam is a well-known illustration of the conversion of heat into motion, and the heat produced by friction, by hammering of metals and by condensation of gases shows *clearly that motion can* be changed into heat.

A given quantity of heat can always be changed into a definite



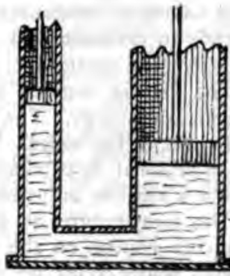


Fig. 3—Hydraulic Press.

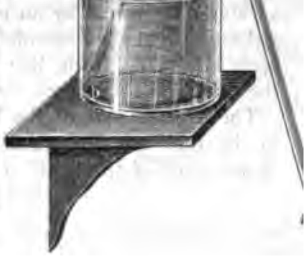


Fig. 5—Suction Pump.

Fig. 6—Syphon.

(From Mueller-Pouillet's Physik u. Meteorologie).

amount of work, and a certain amount of work can produce a corresponding quantity of heat. (See also "Power.")

The "mechanical equivalent of heat" is the numerical relation between work units and heat units.

A "heat unit" is the amount of heat that will raise the temperature of one pound of water one Fahrenheit degree. It is equivalent to 778 foot-pounds , or can lift 778 pounds one foot.

The "heat equivalent of chemical union" has a relation to the fuel values of substances. When a pound of carbon burns completely to carbonic acid, it yields heat enough to raise 8,080 lbs. of water one centigrade degree, or 1.8 Fahrenheit degrees.

The "steam engine" is a device for transforming heat into mechanical energy. The heat of the burning coal is taken up by the water in the boiler. When the boiling temperature is reached all additional heat changes the water into steam, giving the steam a tension, or pressure.

The temperature at which the water boils depends on the pressure resting on the water. If the pressure is four atmospheres, nearly 60 lbs. per sq. in (45 lbs. gauge), the water boils at a temperature of 293° F. The steam issuing from such a boiler has, therefore, a temperature of 293° F., and a pressure of 60 pounds per square inch. This "live steam" enters the cylinder and pushes the piston ahead, causing a "stroke." If the cylinder has a diameter of 8 inches, the area of the piston is 50 square inches, and the total pressure on the piston is 50 × 60, or 3,000 pounds, being 60 pounds per square inch. Toward the end of the stroke the steam in the cylinder may be cut off from the steam in the engine, in which case the pressure of the cut-off steam decreases as the steam expands. At the end of the stroke a valve-rod, moved by an eccentric, shifts a slide-valve into such a position that the expanded or exhaust steam can escape into the open air, while fresh, live steam is admitted from the boiler to the other face of the piston, pressing it back again.

The greater part of the heat-energy produced by the burning of the fuel goes to waste, the steam engine utilizing less than 15 per cent of the heat. (See "Steam Engines.")

ELEMENTS OF MACHINERY.

LEVER.

The lever is a solid body, commonly a bar, which is supposed to be not flexible. It has a fulcrum, or fixed axis, and at least two forces acting upon itself. It is employed to lift weights.

The force which resists the motion of the lever is the load *L*. The force which wants to move the lever is called simply "the force," *F*.

For general calculations the weight of the lever itself is neglected, and the lever considered a straight, not flexible line, which is called a mathematical lever.

When force and load are exerted in the same direction, the lever is a straight lever.

When force and load are exerted in directions at an angle with each other, the lever is an angle lever.

When the fulcrum is located between the two attacking points of load and force, the lever is a two-armed lever.

When the fulcrum is situated to one side of the attacking points of both load and force, the lever is a one-armed lever.

All levers are in equilibrium when load and force are in inverse proportion to their respective lever lengths; or, the products of lever lengths and respective forces must be equal.

When the force and load act vertically upon the lever, the actual length of the lever arms is the length to be used in calculation. When, however, the direction is not vertical, it is the projection of the actual lever upon a line representing the lever vertical to the direction of the forces that must be used for calculation.

TWO-ARM LEVER.

In Fig. 1 $a\,f$ and $a\,l$ are the actual lever lengths, while $a\,f''$ and $a\,l''$ are the lever lengths to be used for calculating the power ex-

erted by force and load. The ways which the respective lever ends have made are $f f''$ and $l l''$ and these must be considered when the work performed is to be calculated. The products of the forces and their projected levers must be equal just as in the case of the actual levers.

We assume that the lever lengths are drawn in feet, and the forces in lines representing pounds.

a = fulcrum; f = the point where the force F attacks; l = the point where the load L attacks; and f', f'', l', l'' subsequent positions of f and l.

We have in Fig. 1

$$F \times f \cdot a = L \times l \cdot a$$

and

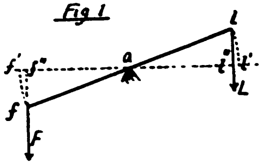
$$F \times f''a = L \times l''a$$

The power exerted by the force at f is $= F \times f''a$.

by the load at l $= L \times l''a$.

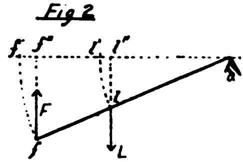
In the case of a two-armed lever, the force and load have the same direction.

Fig 1



Two-Arm Lever.

Fig 2



One-Arm Lever.

The force exerted against the fulcrum is the algebraic sum of load and force. Algebraic sum means the values with the sign attached, indicating their direction, viz.: + and —. If force and load have the same direction, the force exerted upon the fulcrum is $= F + L$. If the force and load have the opposite direction, then the pressure exerted upon the fulcrum is $L - F$, and is exerted in the direction of the larger of the two forces, in this case the load.

ONE-ARM LEVER.

In Fig. 2 we have a one-arm lever, and calling the upward motion "+" and the downward motion "—", we find

$$L \times a\,l = F \times a\,f$$

and

$$L \times a\,l'' = F \times a\,f''$$

The power which can be exerted by each force at f and l respectively, at

$$f = + F \times a f''$$

and at

$$l = - L \times a l''$$

The pressure exerted upon the fulcrum $= L - F$ and negative.

ANGLE LEVER.

Fig. 3 shows an angle lever.

Again

$$F \times a f = L \times a l$$

and

$$F \times a f'' = L \times a l''$$

The powers exerted at f and l, are

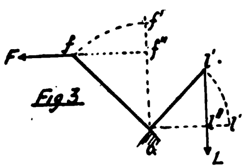
$$F \times a f''$$

and

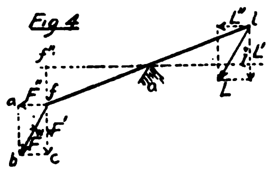
$$L \times a l''$$

but not in the same direction.

The pressure upon the fulcrum in a vertical direction is $= L$, and in an horizontal direction $= F$.



Angle Lever.



Force Diagram.

When the forces do not act either vertically or horizontally, then they must be resolved into their vertical and horizontal components, or the so-called force diagram formed, as shown in Fig. 4.

Force F acts in an angle, and must, therefore, be resolved. Draw through the point at which the force attacks (f) one horizontal and one vertical line, and complete the rectangle by making force f the diagonal. Then, F'' is the horizontal component of F, and represented by the length of line $a f$. F' is the vertical component of force F and represented by line $f c$.

These values are found graphically as just shown. When line $f b$ represents the number of pounds of the force F, in the same scale the line $a f$ represents the number of pounds of F'', and $f c$ the number of pounds of F'.

To calculate F'' and F' when F and the angle of direction are given, remember that

$$c\,b = a\,f = F \times \sin w.$$
$$f\,c = F \times \cos w.$$

further that

$$F^2 = F''^2 + F'^2.$$

Having found the components it is only necessary to find the proper lever lengths in order to know the power exerted at l and f horizontally, as well as vertically.

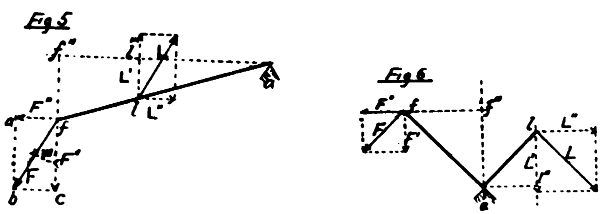
We have exerted on point f the power $= F'' \times f\,f''$ horizontally.
on point f the power $= F' \times f''\,a$ vertically.
on point l the power $= L'' \times l'\,l''$ horizontally.
on point l the power $= L' \times a\,l''$ vertically.

The pressure upon the fulcrum is

$$\text{vertically} = F' + L'$$

and

$$\text{horizontally} = F'' + L''$$



Calculating Force on Lever.

The power exerted by levers in Figs. 5 and 6 can now be calculated according to the directions given when calculating the same for Fig. 4. We only add the pressure upon the fulcrum in Figs. 5 and 6.

In Fig. 5

$$\text{pressure} = +\ (L' - F')\ \text{vertically.}$$
$$L'' - F''\ \text{horizontally.}$$

In Fig. 6

$$\text{the pressure} = -\ (L' + F')\ \text{vertically.}$$
$$= \quad L'' - F''\ \text{horizontally.}$$

If more than two forces are exerted, we have always to consider the algebraic sum of the same, which must be $= 0$ to give equilibrium. Fig. 7 shows such lever where the power exerted by the forces on one side on their respective levers must be

$$(-F'') \,.\, af'' + (+F') \,.\, af' + (+F) \,.\, af =$$
$$(+L'') \,.\, al'' + (-L') \,.\, al' + (-L) \,.\, al$$

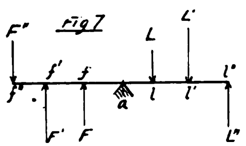
and the pressure on the fulcrum

$$(-F'') + (+F') + (+F) + (+L'') + (-L') + (-L)$$

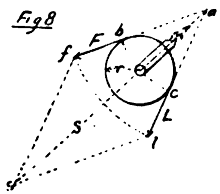
SNATCH BLOCK.

The snatch block (Fig. 8) is used to change the direction of the force, and not to increase the load for a given force. The load and force must be the same.

If $f\,a$ and $l\,a$ represent F and L, which are equal, then the resulting pressure (S) exerted upon the pin of the fork holding the



Lever where more than two forces are exerted.



Snatch-block.

pulley, and finally upon the hook to which the fork is attached, is to F as the distance connecting the two points where the rope touches the pulley, to the radius of the pulley, or

$$S : F = bc : r.$$

S is represented by the line $a\,s$, which also gives the direction of the force S, which is the amount of pounds of pressure exerted against the hook carrying the snatch block.

If the ropes are parallel, that is to say, the direction of force and load parallel, then

$$b\,c = 2\,r$$

and

$$S : F = 2\,r : r$$

or

$$S = 2\,F.$$

SINGLE LOOSE BLOCK.

A single loose block (Fig. 9) is used to increase the load which a certain force can lift, the time of lifting being proportionately increased. The rope is fastened at one end to a solid hook, and at the other end the force is applied, the pulley is free to move on the rope and carries the load by a fork which pivots the pulley.

The force exerted at the hook to which the rope is fastened equals the force exerted at the other end of the rope.

The load S which can be lifted by a certain force F is, again,

$$S : F = bc : r$$

as before. If the rope ends are parallel,

$$S : F = 2r : r$$

and

$$S = 2F.$$

WHEEL (ROPE) AND HOISTING DRUM.

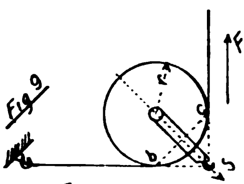
A wheel and hoisting drum is shown in Fig. 10.

R = radius of wheel; r = radius of drum;

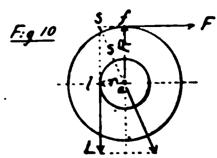
$$L \times r = F \times R$$

or the load which can be lifted by a certain force F

$$L = F \frac{R}{r}$$



Single Loose Block.



Wheel and Hoisting Drum.

and the total pressure on both supports when both are exerted in the same plane = S.

Construct force diagram $s\ f\ a\ l$; then $S = a\ s$, the force exerted against the supports and one-half of the pressure for each bearing. Or

$$S^2 = L^2 + F^2; \text{ or } S = \sqrt{L^2 + F^2}.$$

THE INCLINED PLANE.

Fig. 11 shows an inclined plane. A body L is lying on an inclined plane, and a force F is to be exerted in the direction of the incline to hold L in place. Make

$$F : L = bc : ac$$

then

$$F = \frac{bc}{ac} \times L$$

and

$$F = \sin w \times L.$$

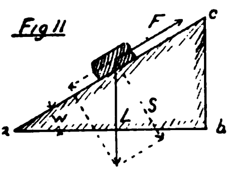
[redacted]

Force vertical against plane

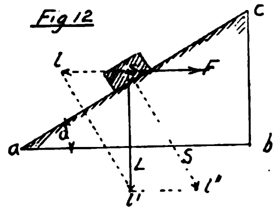
$$S = \cos w \times L.$$

The force is directed in horizontal direction (Fig. 12).

Draw the force diagram, resolving L into two components, one vertical to the plane and the other horizontal, mawe $sl = F$,



Inclined Plane.
Force in direction of plane.



Inclined Plane.
Force in horizontal direction.

and $sl'' = l'\ l = S =$ the vertical force of the load on the plane.

$$\text{Then } S : L = ac : ab \text{ or } S = \frac{ab}{ac} \times L,$$

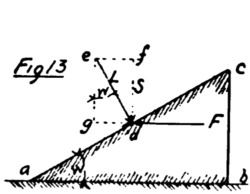
$$F : L = bc : ba \text{ or } F = \frac{bc}{ba} \times L,$$

$$\text{or } F = \tan w \times L.$$

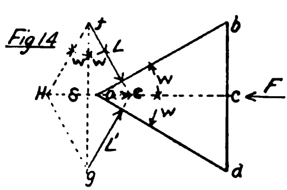
THE WEDGE.

In a wedge (Fig. 13) the load is exerted vertically to the tapering side of the wedge.

$$F : L = cb : ac.$$



Wedge.



Double Wedge.

The wedge is in equilibrium when

$$F = gd$$

and

$$S = fd$$

and

$$F = \sin w \times L$$
$$S = \cos w \times L.$$

DOUBLE WEDGE.

A double wedge is shown in Fig. 14. L and L' are the two loads exerted vertically to the two tapering sides of the wedge. Draw the force diagram through the ends of L and L', viz.: f and g; then

$$L = fe$$

and

$$L' = ge.$$

The resulting force of both $= S$ must be $= F$ to have an equilibrium

$$he = S$$
$$F : L = bd : ab$$
$$F = 2 L \times \sin w.$$

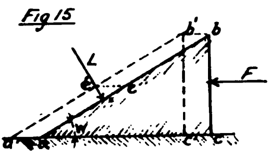
SINGLE WEDGE MOVING.

When a wedge (Fig. 15) moves from a to a', then $e'\ g$ is the way the force has made, and ee' the way the load has made. Make

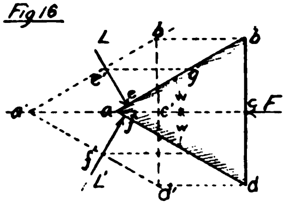
$$ab : bc = L : F$$

then

$$ge' : ee' = L : F.$$



Single Wedge Moving.



Double Wedge Moving.

DOUBLE WEDGE MOVING.

When the wedge (Fig. 16) moves from a to a' then

$$aa' = e'\ g.$$

The way the force has made $= e'\ g$
and the way the load has made $= ee' + ff$. Make

$$ab : bd = (L + L') : F.$$

then

$$ge' : (ee' + ff') = (L + L') : F,$$

Again, the load is guided so that it cannot slip on the plane, and acts vertically. (Fig. 17.)

Draw the force diagram for L, one component vertical to the *taper. Force ge will* be absorbed by the wedge. Force je will *be absorbed by the* guide of the vertical force. The force ge

which was absorbed by the wedge, by drawing the power diagram, gives the components *he* and *fe*.

$$fe = L$$

and is resisted by the sliding plane with the force $= S$; therefore

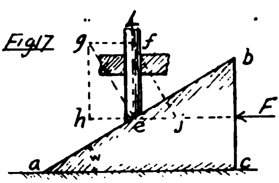
$$S = L$$

he is resisted with equal force by force F; $fe = gh$.

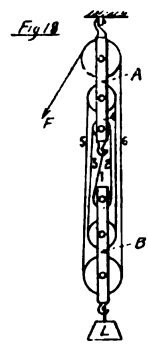
$$F : L = he : gh = bc : ac$$

$$F = L \times tan.w.$$

If the wedge moves a little, under the same conditions as above, then the way of the load is in proportion to the way of the force, as the force to the load.



Single Wedge Moving.



Block and Fall.

THE SCREW.

The mathematical definition of a screw is the single wedge sliding along the surface of a cylinder. The line produced, therefore, on the surface of the cylinder, forms the same angle with the side of the cylinder everywhere.

The actual cutting of the thread can be best followed by the action of the lathe. The cutting tool has the shape of the thread, the motion of the tool rest is in conformity with the pitch of the screw, and the direction in which the tool rest moves, determines the hand of the screw. If the tool is formed square, a square thread is obtained; if formed with a point, the sharp thread is obtained. When the tool rest moves from right to left *the right hand* thread is produced, and vice versa.

Looking at the screw itself, the side which rises determine

the hand of the thread. If it rises to the right, it is a right hand thread; if to the left, it is a left hand thread, while in a nut the directions are reversed. The thread on the screw is called the male, and the thread in the nut the female thread.

There are three standard kinds of thread, the square, the sharp, and the rounded corner one. When, after one thread has been cut, forming one continuous line, a second or third line is cut between the lines formed by the first cut, the screw is a double or triple one.

Mechanically, we can consider the screw as a wedge, having for the back the pitch of the screw and for the base the circumference of the screw, and therefore, we apply the laws governing the wedge receiving the force parallel to the sliding plane (vertically to the axis of the screw exerted at the circumference) and the load vertically to the sliding plane (parallel to the axis of the screw).

If we call p the pitch of the screw, u the circumference of the screw, and d the diameter of the screw, F and L the forces, we have to put in the formula

the back of the wedge $bc = p$

the base of the wedge $ab = u$

therefore,

$$F : L = p : u.$$

In order to avoid much explanation we will hereafter call the way the force makes, the force way, and the way the load makes, the load way.

$$\text{Load way} : \text{force way} = F : L.$$

If the screw is turned by a pin inserted into the head of the screw vertically to the axis and going through the same, we have the case of the wheel and drum.

Calling R the distance from the axis to the point where the force attacks, the force required there $= F$ to lift the load is

$$F' \times R = F \times r,$$

when r is the radius of the screw. And

$$F' = F \frac{r}{R}.$$

We had

$$F = L \frac{p}{u}$$

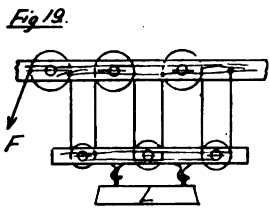
therefore,

$$F' = L\frac{pr}{Ru} = L\frac{pr}{Rd\,\pi} = L\frac{p}{2R\,\pi}.$$

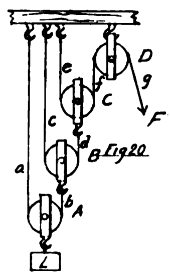
If the screw made one revolution, the force way is $= 2R\,\pi$, and the load way is $= p$.

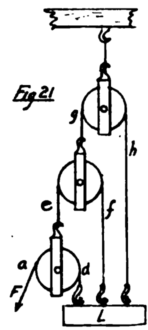
BLOCK AND FALL.

Neglecting the stiffness of the rope, we can easily study the action of the block and fall. We know that each single block must be in equilibrium, and that the tension in the same rope must be the same all over.



Block and Fall.





Combination of Single Blocks.

COMMON BLOCK AND FALL.

In Fig. 18, *A* is the block and *B* the fall, and one continuous rope goes over all pulleys. The number of pulleys in the block = the number of pulleys in the fall = n; then

$$F = \frac{1}{2n}L.$$

Since we have n pulleys it is evident that the load hangs on $2n$ ropes, which have all the same tension, as explained before; therefore, the tension in one

$$F = \frac{1}{2n}L.$$

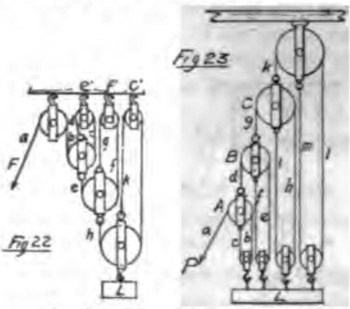
The arrangement of the pulleys might be as in Fig. 19, which is preferable *when long pieces are to be lifted, as they can easily be balanced. The* upper pulleys are pivoted in a beam resting

on posts or walls, while the lower pulleys are pivoted in a loose beam provided with hooks to receive the load.

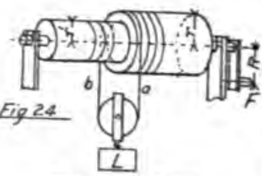
COMBINATION OF SINGLE BLOCKS.

In Fig. 20 the ends of the ropes of each single block are secured to a fixed beam at one end, and to the hook of the next single pulley, at the other end. The rope from the last single loose block must be passed over a snatch block.

Fig. 21 shows a series of snatch blocks connected together. The ropes are fastened with one end to the load and with the other



Combination of Single Blocks.



Differential Drum.

end to the hook of the next snatch block, and the last to where the force is exerted. Each pulley has a separate rope.

If we have n loose pulleys attached to ropes only we find

$$F = \frac{1}{2^n} L.$$

This block and fall is called the "potential."

The load acts first on the loose pulley A, and since each part of the rope has an equal tension, the tension in each $= \frac{1}{2} L$. The loose pulley B has to carry only as much as rope $l = \frac{1}{2} L$, therefore, each rope c and d has to carry only $= \frac{1}{4} L$. The pulley C then carries only as much as rope $d = \frac{1}{4} L$, and, therefore, the ropes c and f only one-half of this each $= \frac{1}{8} L$, and the force against the hook, carrying the snatch block, must be $= 2 \times \frac{1}{8} L = \frac{1}{4} L$.

The values 2, 4, 8, are evidently potentials of 2, whence the name of the block and fall. We can therefore write the formula, if n is the number of the loose pulleys

$$F = \frac{1}{2^n} L.$$

Negative forces are F and L, and their sum $= \frac{9}{8} L.$

Positive forces are the tensions in the ropes,

$$a = \tfrac{1}{2} L. \qquad c = \tfrac{1}{4} L. \qquad e = \tfrac{1}{8} L.$$

The force exerted upon the hook of the snatch block was $= \tfrac{1}{4} L'$, and the sum of all these positive forces is again $= \frac{9}{8} L.$

In Fig. 21 each rope carries one-quarter of the load, and its tension is therefore $= \tfrac{1}{4} L$. The force against the hook is $= F + L$, and if we call n the number of loose pulleys, then

$$F = \frac{1}{2^{n+1} - 1} L.$$

Fig. 22 shows another arrangement where each pulley has two hooks, with the exception of the last, the snatch block. The tension in each rope must be the same; hence, the tensions $a = b = c = d = F$. Then the tensions e, f, g, must be each $= 3\,F$, because the tension e must be equal tensions $b + c + d = 3F$. The tensions h, i, k must each be $= 9\,F$, because

$$h = e + f + g = 3 \times 3\,F = 9\,F.$$

The load is carried by h, i, k, therefore

$$h + i + k = 3 \times 9\,F = 27\,F,$$

then

$$F = \frac{1}{27} L,$$

or since 27 is the third power of 3,

$$F = \frac{1}{n^3} L,$$

$n = 3$ in this case.

Against the hook of the fast pulley D is exerted a force $= a + b = 2F$, and upon pulley $e' = d + c = 2\,F$,

pulley $f' = g + f = 6\,F$,

pulley $c' = i + k = 18\,F$.

The whole beam has to carry

$$F\,(2 + 2 + 6 + 18) = 28\,F = L + F.$$

Fig. 23 shows the reverse arrangement. Again we have

$$a = b = c = F,$$

being the tensions in the same rope; and for the same reasons

$$d = e = f = 3F,$$
$$g = h = i = 9F,$$
$$k = l = m = 27F.$$

The load is carried by the ropes b, c, e, f, h, i, m, which give

$$F(1 + 1 + 3 + 3 + 9 + 9 + 27 + 27) = 80F;$$

therefore,

$$F = \frac{1}{80} L = \frac{1}{3^{n+1} - 1} L$$

(we have n pulleys with double hooks).

The fixed hook has to stand a pressure equal to the tension of the ropes $k, l, m = k + l + m = 3 \times 27 \times F = 81F = L + F$.

DIFFERENTIAL DRUM.

The differential drum (Fig. 24) works just like a single drum of the radius $= \dfrac{r - r'}{2}$; if we call R = crank radius, r = large drum radius, r' = small drum radius. Each of the ropes a and b has a tension $= \frac{1}{2} L$; the tension in b is exerted in the same direction as F, while the tension in a is in the opposite direction. Hence, we have:

$$F \times R = \tfrac{1}{2} L r - \tfrac{1}{2} L r'$$

or

$$F = \frac{L(r - r')}{2R}.$$

and if two cranks are used

$$F' = \frac{L(r - r')}{4R}.$$

The differential drum has the advantage that a larger load can be lifted with it than with a single drum.

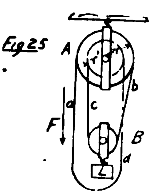
The radius of the crank being a fixed length, given by the most convenient length for the man operating the crank, the drum can have only a certain minimum radius in order to be strong enough to carry the load. This radius, compared with r', the radius of the smaller one of the differential drum is $\frac{1}{2}(r - r')$.

If the crank is 12" long and the smaller drum of the differential drum equals the radius of the single drum, and the larger drum of the differential is 4", then we have, in the case of the single drum, a leverage of 1:12, while the differential drum has a leverage of 1:24, which would not have been possible with the single drum.

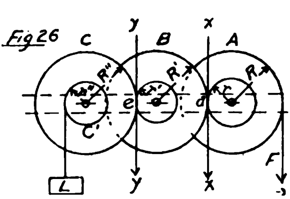
In one case the load way is $\frac{r}{R}$, and in the other case $= \frac{r - r'}{2R}$; or, inserting the figures $= \frac{1}{12}$ and $= \frac{2-1}{2 \times 12}$, respectively, we have $\frac{1}{24}$, or just twice as much.

DIFFERENTIAL BLOCK AND FALL.

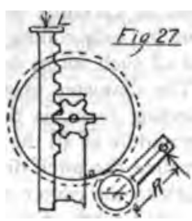
The block has two chain wheels on the same shaft, both being keyed to it. The chain is endless, and placed, as shown in Fig. 25, so that two complete loops are formed. In one of the loops a loose pulley is suspended, and the other loop is used for applying the force. The loose pulley carries the load. Since one part of the chain has no tension, the upper chain pulleys must be provided with sprockets or recesses to prevent the slipping of the chain.



Differential Block and Fall.



Gears.—Three pairs.



Geared Jack.

r = radius of large chain pulley; r' = radius of small chain pulley. Then

$$F = \frac{L\,(r - r')}{2r}$$

because

$$F\,r + \tfrac{1}{2}\,L\,r' = \tfrac{1}{2}\,L\,r.$$

Since the chain pulleys have either sprockets or recesses,

number of them can be used instead of the radius. If we call them n and n', respectively, we have

$$F = \frac{L\,(n - n')}{2n}.$$

If, therefore, the one chain pulley has 22, and the other 20 sprockets or recesses, we have

$$F = \frac{L\,(22 - 20)}{44} = \frac{1}{22} L.$$

When the force F is not exerted, the friction on the pivot of the block will generally be sufficient to hold the load in place. In other words, the chain need not be held, if the load remains suspended from the tackle, which is a great convenience in handling machinery.

GEARS.

If two cylindrical wheels are pressed against each others' surfaces, they can transmit power to each other, but in most cases this friction would not be sufficient for the power required, and the wheels would slip. Hence, rough surfaces must be given to them or projections, called teeth, and recesses to engage them. in order to prevent slipping. The form of these so-called teeth must be carefully designed so that there will be no sliding friction, but only rolling friction. The teeth are given different forms, but all such forms conform to the above-mentioned conditions.

The diameter of a gear, which only is to be considered when selecting them. is the diameter of a circle going through about the middle of all the teeth. called the pitch line. while its diameter is called the pitch diameter. The distance from the center of one tooth to the center of the next tooth measured on the pitch line, is called pitch of the gear.

If the outer diameter of the gear is given—which must be done as the gear body must be first turned to it in the lathe—and the number of teeth is given, the pitch diameter is obtained by subtracting from the outside diameter, 0.6 of the pitch; then divide the circumference of this circle by the number of the teeth. and the result must be the pitch. The figure 0.6 is twice the height *of the tooth above* the pitch line. while 0.4 is the distance to the *foot of the tooth from* the pitch line. Hence, total height of *ooth = 0.7 of pitch.*

The diameters of two circles (wheels) are in direct proportion to their circumferences, and the same proportion must prevail between the numbers of the respective teeth of each wheel which we will call $= n$, and the pitch $= p$.

Fig. 26 represents three pairs of gears, of which two pairs act upon each other, while the load is attached on the periphery of the pinion to the left, and the force exerted on the periphery of the large gear at the right hand. The load, as well as the force, might be represented again as gears, or might be weights attached by means of ropes.

As these gears represent simply levers when considered at standstill, we must use the laws there given. If we have equilibrium, we must have it in any part of the system; therefore, also, at the points where the forces X and Y are located, and we have

$$F \times R = X \times r,$$
$$X \times R' = Y \times r',$$
$$Y \times R'' = L \times r''.$$

By multiplying the three equations we get another equation which will express the relation of force and load.

$$F \times X \times Y \times R \times R' \times R'' = L \times X \times Y \times r \times r' \times r'',$$

since X and Y appear on both sides we can cancel them, and have

$$F \times R \times R' \times R'' = L \times r \times r' \times r''.$$

The force way is again in proportion to the load way as the load to the force.

To find the number of revolutions the gear will make which carries L on its circumference, when the revolutions of the wheel receiving the force are given, calling the number of teeth of each wheel Z, Z' Z'', z, z', z'', and the number of revolutions of gear $A = N$, and of gear C or C' on the same shaft $= n$, we have

$$N : n = Z' \times Z'' : z \times z'.$$

GEARED JACK.

In the geared jack (Fig. 27) we have crank radius $= R$; number of teeth of pinion $= z$; number of teeth of gear wheel $= Z'$; pitch radius of pinion for rack $= r$. Then

$$F \times R \times Z' = L \times r \times z,$$

and

$$L = \frac{F \times R \times Z'}{r \times z},$$

the load which can be lifted by the exertion of F on the crank.

TWO INCLINED PLANES.

Upon two inclined planes AB and BC of the same height BD (Fig. 28) rest two weights F and L, which are connected by a cord running over a pulley at B. If the ropes a and b are parallel to the respective inclined planes, we have equilibrium when $F : L = BC : AB$.

The tension in the cord a must be $= L \frac{BD}{AB}$,

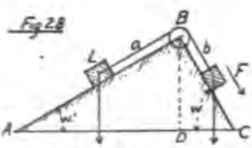
and in cord b must be $= F \frac{BD}{BC}$.

But since both must be equal, being parts of the same rope,

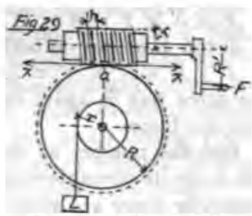
$$\frac{L}{AB} = \frac{F}{BC}, \text{ or } F : L = BC : AB,$$

or

$$F = L \frac{\sin w'}{\sin w}.$$



Two Inclined Planes.



Worm and Worm-wheel.

WORM AND WORM WHEEL.

The load L (Fig. 29) hangs on a rope wound around drum with radius r, which is keyed to the same shaft with a gear of the radius R. A crank with the radius R' is secured to the same shaft with the worm, the pitch of the latter is $= h$. Both shafts are pivoted vertically to each other by the same frame

$$F \times 2 R R' \pi = L h r.$$

In order to have equilibrium in the whole system, we must have it at a also. We assume that the forces X are exerted there. Then

$$F \times 2 R' \pi = X h,$$
$$X R = L r.$$

Multiply the two equations.

$$F X 2 R R' \pi = L X h r;$$

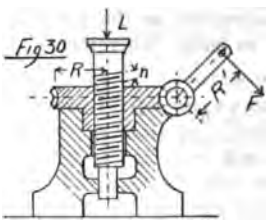
X being on both sides, is canceled.

$$F 2 R R' \pi = L h r.$$

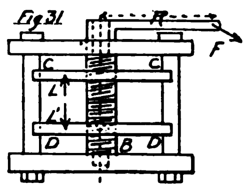
SCREW JACK WITH WORM AND WORM WHEEL.

In order to increase the power of an ordinary screw jack a worm wheel is pivoted in the jack frame (Fig. 30) and receives the female thread corresponding to the male thread on the screw. This worm wheel is actuated by a worm and crank, and is prevented from turning by a square at the lower end. Radius of crank $= R'$; radius of worm gear $= R$; pitch of worm $= h'$; pitch of screw $= h$. Then

$$F 4 R R' \pi^2 = L h h'.$$



Screw Jack with Worm and Worm-wheel.



Differential Screw.

Considering again the equilibrium at the point of contact of worm and worm wheel, and calling the force there "X," we have

$$X 2 R \pi = L h,$$
$$F 2 R' \pi = X h'.$$

Multiplying both equations and

$$X F 4 R R' \pi^2 = L X h h',$$

X is canceled, and we have

$$F 4 R R' \pi^2 = L h h'.$$

DIFFERENTIAL SCREW.

In order to increase the power of a screw filter press, we can use a screw having a coarser and a finer thread, the coarser in the upper press plate, and the finer in the lower press plate (Fig. 31).

It is evident that since both screws move the plates in the same direction, both threads being of the same hand, the upper press *plate cannot* compress as fast as it descends since the lower pres

plate recedes slowly from it and at the same time reduces the load way, and consequently increases the load, which force R can handle. We call h the pitch of coarser screw; h' the pitch of finer screw; R the radius of crank. Then

$$2\pi FR = L(h - h').$$

The load in this case is a force directed against the two press plates, but in the opposite direction to the force. To have equilibrium for press plate C C

$$F' = \frac{Lh}{2R\pi},$$

for press plate D D

$$F'' = \frac{L'h'}{2R\pi}.$$

The force F'' works in the same direction as the force at the crank, while the force F' is opposed to both. Therefore,

$$F' = F + F'',$$

or

$$F = \frac{Lh}{2R\pi} - \frac{L'h'}{2R\pi};$$

but

$$L = L';$$

therefore,

$$F = \frac{L(h - h')}{2R\pi}.$$

PRINCIPLES OF VIRTUAL VELOCITY.

If in a machine more than one force is applied, the force ways and the load ways must be considered separately.

We allow only the smallest possible movement, and call it the "virtual velocity" of the force, and the product of the force and this virtual velocity, the "virtual moment." The product of force multiplied with its proper lever is called the "moment" of the force.

$$\frac{\textit{force}}{\textit{load}} = \frac{\textit{load way}}{\textit{force way}} = \frac{v}{V}$$

or, force way $\times$ force $=$ load way $\times$ load.

If the force is not exerted in the direction the point travels, *the force way is the projection* of the point way upon the force *direction.*

If $F < L$ we have saving of power.
If $F > L$ we have loss of power.
If $V > v$ we have loss of time because the force makes a longer way.
If $V < v$ we have gain of time because the force makes a shorter way.

Saving of time or force = a mechanical gain.
Loss of time and force = a mechanical loss.

And in every machine the loss must equal the gain, because

$$\frac{L}{F} = \frac{V}{v}; \text{ or, } \frac{F}{L} = \frac{v}{V}.$$

No machine can save force and time at the same time.

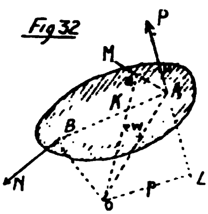
The virtual velocities are considered "positive" when they are in the direction of the force, and "negative" if in the direction of the load.

We return to Fig. 23 to prove that where we lifted a load by one-eightieth part of the force applied, we required eighty times the time to do so, as if we had lifted the load directly. If the load is raised 1" each of the ropes *l* and *m* are shortened 1". Consequently *k* is shortened 2", and the pulley *C* sinks 2", coming 3" closer to the load, since the latter was raised 1". This makes the ropes *h* and *i*, 3" shorter, and therefore, g, 6" longer, and the pulley *B* has sunk 6" from pulley *C*, or a total distance of 8" from the beam, and the load is now $8 + 1 = 9$" closer to the pulley *B*, rope *k* being shortened 1". The pulley *B* in sinking has shortened ropes *e* and *f* by 9" each; therefore, rope *d* must be shortened 18", and the pulley *A* sinks $18 + 8 = 26$", and comes closer to the load by $26 + 1 = 27$". This movement of the pulley *A* shortened each rope *b* and *c* by 27", and *a* therefore by 54". Since, however, pulley *A* has sunk 26", the force *F* attached to rope *a* must have moved $54 + 26 = 80$".

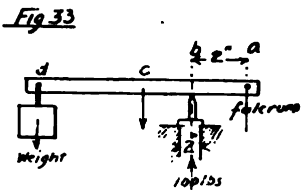
LAWS OF VIRTUAL VELOCITY.

When more than one force is exerted upon a body, we have equilibrium if the sums (Σ) of all products of force and virtual velocities are $= 0$; or if the algebraic sum of the virtual moments is $= 0$. When two forces are exerted at different points of a body, and act in different directions, we can consider that *both will turn the body* around a common center. This center *need not to be a part of* the body, but can be outside of it.

We have a body K and two forces P and N exerted at the points A and B of the body in the directions AM and NB (Fig. 32). If we now consider the movement a very small one, we can assume that this movement was vertical to the radius drawn from a common center. We, therefore, find this common center by drawing two vertical lines to AM and NB. Where they meet is point O, the common center around which all points of the body must turn. If point A has moved to a on line AM, then the body K has turned an angle w, and all points with it. Force P attacks in A, and the projection of the force way upon the force line P is Au, which gives the corrected virtual velocity of point $A = v$.



Laws of Virtual Velocity.



Safety Valve.

In order to get the virtual moment, we must first find the correct lever, by drawing OL vertical to AP or, in this case, to its continuation, so OL is the correct lever for $P = p$. Therefore,

$$\frac{Au}{Aa} = \frac{p}{OA},$$

and since $Aa = OA.w$, and $Au = v$.

$$Pv = Pp.w.$$

If we have more forces P it is as stated before:

$$\Sigma\ (P\,v) = \Sigma\ (P\,p.w) = w.\ \Sigma\ (P\,p).$$

To have equilibrium, therefore,

$$\Sigma\ (P\,p) = o,$$

and consequently

$$\Sigma\ (P\,v) = o.$$

For example, we apply this law to the differential screw (Fig. 31). Since the motion is uniform, we can take a whole turn instead of a small motion only. The force way $= 2\,\pi\,R$; the virtual moment of F is $= F\,2\,R\,\pi$. The press plate CC sinks the height h, and against the load L. Hence, the virtual velocity of L must be $-\,h$, and the virtual moment $= -$ Lh. The press plate

DD sinks h', but the load acts in the same direction as the force. Hence, h' = the virtual velocity of L', and Lh' the virtual moment of L'.

The equation of the equilibrium is

$$F\,2R\,\pi - L\,h + L'\,h' = 0,$$

or

$$F\,2R\,\pi = L\,(h - h'),$$

or the same result as we had before.

SAFETY VALVE.

A safety valve (Fig. 33) has a two-inch opening, against which 100 pounds' pressure is exerted from the boiler. A single arm lever is provided 25″ long over all, the valve stem presses against the lever 2″ from the fulcrum, and the weight is to be attached 24″ from the fulcrum. The valve weighs two pounds, and the lever is made of ¼ by 1½ flat iron.

Since, in reality, no lever is a mathematical lever, we must take the weight of the lever into consideration. The weight of it is $= 0.25 \times 1.5 \times 25 \times 0.27 = 2.53$ lbs. The influence of the weight of the lever can be considered as a force which is negative and attacks the mathematical lever at the center of gravity of the lever, which, in this case, is one-half of its length $= 12''$. The weight of the valve, although it has but little influence, should also be taken in account. The valve acts negatively, and at 2″ from the fulcrum, and the pressure against the valve from below is $3.14 \times 100 = 314$ lbs. It acts also on a lever of 2″ in a positive sense.

Having determined all levers and forces, including their directions, we can now form the algebraic sum of all virtual moments, calling the weight we want to find $= x$.

Moment of steam pressure $= 314 \times 2 = 628$ ft. lbs. positive.
Moment of weight of valve $= 2 \times 2 = 4$ ft. lbs. negative.
Moment of weight of lever $= 2.53 \times 12 = 30.3$ ft. lbs. negative.
Moment of weight necessary $= x \times 24$ ft. lbs. negative.
Adding all moments

$$(+\,628) + (-\,4) + (-\,30) + (-\,24x) = 0.$$
$$628 - 34 = 24x,$$
$$x = 24.7 \text{ lbs.},$$

which is the weight that must be suspended at 24″ from the fulcrum to prevent the valve from lifting below 100 lbs. pressure.

RAISING BARREL WITH ROPE AND SKID.

Two men pull on one rope each, the end of each is fastened to the top of the skids. The barrel is raised by rolling up an inclined plane (Fig. 34). The force $= 2\ P$; the weight of the barrel $= L$; ab is the depth of the cellar, and ac the length of the skids.

We have the case of a body resting on an inclined plane, the force exerted in the direction of the plane, and the load vertical to it. The formula for this was:

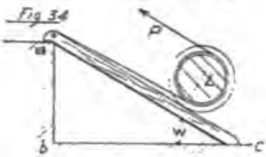
$$\frac{force}{load} = \frac{height\ of\ plane}{length\ of\ plane}.$$

$$\frac{2\,P}{L} = \frac{ab}{ac},$$

if $ab = 4'$, and $ac = 12'$, and $L = 300$ lbs., then

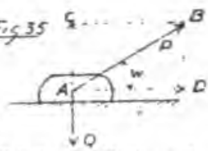
$$P = \frac{L}{2}\ \frac{ab}{ac} = \frac{4 \times 300}{12 \times 2} = 50\ lbs.$$

Fig 34



Raising Barrel with Rope and Skid.

Fig 35



Friction on Horizontal Plane.

FRICTION.

When a body lies over another and each has an absolutely perfect surface, the least exertion of a force would cause one to slide over the other. But there is no possibility of obtaining perfect surfaces. All surfaces which we can produce are rough when examined under the microscope, and exhibit quite a lot of projections and recesses which prevent the sliding of one body over the other, since the one body must be slightly raised before its projections can pass the projections of the other. The case is illustrated best by two small pieces of glass ground in the most *perfect* way against each other. If their surface was entirely with*out recesses and they* were rubbed together, all the air would be *expelled and a perfect* contact created. But nothing like

[redacted]

this occurs. When, however, a little fine tallow is rubbed over both, in other words, the little recesses filled with tallow and the plates then pressed tightly together, all the air will be expelled, and it is extremely difficult to separate the plates by lifting without breaking them, when once placed together.

We consider first two conditions of motion: Friction of a body starting to move, and friction of a body when in motion; second, sliding and rolling friction and another kind of sliding friction, viz.: The pivot friction.

SLIDING FRICTION.

The resistance offered by one body sliding over the other is called the "frictional resistance." The surface of the contact is called "frictional surface." The ratio of the force creating the friction, to the friction created, is the "friction coefficient."

1. Frictional resistance increases with the force.
2. Frictional resistance is independent of the frictional surface.
3. Frictional resistance is reduced per square inch of frictional surface if the latter is increased while the pressure remains the same.
4. Frictional resistance depends on the condition and nature of the frictional surfaces. Smooth and hard surfaces have less frictional resistance than rough and soft surfaces, and making the surfaces smooth by using lubricants as in the case of the two glass plates mentioned, will reduce the frictional resistance.
5. Frictional resistance when starting to move is greater than when in motion.
6. Frictional resistance while the body is in motion is independent of the velocity of the moving body.
7. Pivot frictional resistance is less than sliding frictional resistance.

ACTION OF FRICTIONAL RESISTANCE.

1. Frictional resistance is exerted in the plane of the frictional surfaces, and in opposite direction to the moving force.
2. Frictional resistance between two bodies, one moving faster than the other, helps the slower one, and retards the motion of the faster one.

5. Frictional resistance of two bodies moving in [illegible] [illegible] directions exceeds the motion of both bodies.

TABLE OF FRICTION COEFFICIENTS.

Description of the bodies under friction.		Dry.	Moist.	Olive oil.	Pig lard.	Tallow.	Pig lard with graphite.	[illegible]	Dry soap.
Wood against wood.	Minimum value	0.20	....	....	0.[illegible]	0.0[illegible]	....	....	0.[illegible]
	Mean value	0.3[illegible]	0.25	....	0.07	0.07		..	0.[illegible]
	Maximum value	0.4[illegible]	....	....	0.07	0.0[illegible]	....	....	0.[illegible]
Metal against metal	Minimum value	0.15	....	0.0[illegible]	0.07	0.07	0.1[illegible]	0.12	....
	Mean value	0.18	0.31	0.07	0.0[illegible]	0.0[illegible]	0.0[illegible]	0.15	0.2[illegible]
	Maximum value	0.24	....	0.0[illegible]	0.11	0.11	0.0[illegible]	0.17	....
Metal against wood or reverse	Minimum value	0.20	..	0.05	0.05	0.06	....	....	....
	Mean value	0.42	0.2[illegible]	0.0[illegible]	0.07	0.0[illegible]	0.0[illegible]	0.1[illegible]	0.2[illegible]
	Maximum value	0.62		0.1[illegible]	0.0[illegible]	0.1[illegible]	....	....	....
[illegible] against	Wood	0.4[illegible]	0.2[illegible]	....	....	....	....	....	....
	Metal	....	....	0.15	..	0.19	....	....	....
Sole leather with surface against wood or metal	Rough	0.54	0.2[illegible]	0.1[illegible]	...	0.20	....	....	....
	Hammered	0.30	..	....	....	....	....	....	....
Sole leather with edge against wood or metal	Dry	0.36	0.31	0.14	....	....	....	....	....
	Lubricated		0.24	....		....	....	....	....
Dry [illegible] wood [illegible]		0.34	..	..		....	....	....	....
[illegible] [illegible]		....	0.3[illegible]	.	.	.	....	....	....
[illegible] dry wood		0.4[illegible]	.	.	.	.	....	....	....

FRICTION ON HORIZONTAL PLANE.

Let m (Fig. 35) be the frictional coefficient, and the force P be exerted in an angle w against the sliding plane. Then we have equilibrium if

$$P = \frac{mQ}{\cos w + m \sin w}.$$

Draw the force diagram for P, the horizontal component being AD and the vertical component AC.

$$AD = P \cos w,$$

$$AC = P \sin w.$$

The pressure against the plane is, therefore,

$$AC = Q - P \sin w.$$

(the direction of AC is opposite to that of Q), and the frictional resistance is represented by the proportion of the force or weight exerted upon the body vertically to the frictional surface which is required to overcome the friction. Therefore,

$$\text{frictional resistance} = m\ (Q - P \sin w).$$

The force necessary to move the body in the direction of the

plane must be equal to it

$$AD = P \cos w = m\,(Q - P \sin w).$$

If the angle $w = o$, or the force exerted in the direction of the plane, we have $AD = m\,Q$, and $m = \frac{P}{Q}$.

In order to determine the coefficient m it is only necessary to place a body of a certain material of which we want to know the coefficient of friction when sliding over another body of other or same material, in such a position that their frictional surface is horizontal, attach a cord to the body to be moved (if a cube, to the center of the height and width) leading the cord over a pulley. The weight is suspended from the other end of the cord, being gradually added to until the body starts sliding. This weight is $= P$, the load $= Q$, and $m = \frac{P}{Q}$.

Every body has a frictional angle (e). If placed in this angle it will not slip, while a little larger angle will allow it to do so. Soil or sand, if used for an embankment, will of itself form this angle e when thrown on top and allowed to settle on its own account.

FRICTIONAL ANGLE OF A BEAM.

CH represents the weight of the beam, also the direction in which this weight, = force *P*, is exerted. Gravity acts vertically to the surface of the earth since it is directed to the center of the same (Fig. 36). Draw the force diagram *CBHA*, then *CB* the component against *B*, and *CA* the component against *A*. Place *S* in the center of *HC*. Then the frictional angle of the force against the wall is *DBC*, and against the floor *GAC*, the angle formed by the direction of the force and a vertical to the sliding plane.

These angles must not be larger than the respective frictional angles e and e' and correspond to the coefficients m and m'. If we now draw the force diagram for *CB* and *AC*, constructing the vertical and horizontal components for each, we have *AG* acting vertically in point *A* to the sliding surface, and force *DB* acting in point *B* vertically to the sliding surface, and since the coefficients express the ratio between force and friction, we have

$$m' = \frac{CD}{DB}, \text{ and } m = \frac{AF}{CF},$$

$$AF = \tfrac{1}{2}\, AE = \tfrac{1}{2}\, l \cos w,$$

if l = length of beam.

We had

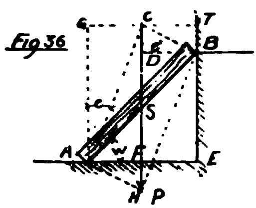
$$CD = m'\, DB = m'\, AF = m' \frac{l}{2} \cos w,$$

and

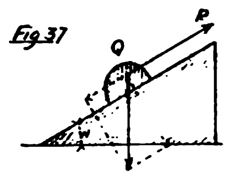
$$BE = DF = l \sin w.$$

Therefore,

$$CF = DF + CD = l \sin w + m' \frac{l}{2} \cos w = \frac{l}{2}\,(2 \sin w + m' \cos w)$$



Frictional Angle of a Beam.



Friction on Inclined Plane.

$$AF = m\, CF;\ \text{therefore,}\ \frac{l}{2} \cos w = \frac{l}{2}\, m\,(2 \sin w + m' \cos w),$$

or

$$\cos w = 2\, m \sin w + m\, m' \cos w,$$

divide equation by $\cos w$.

$$1 = 2m \frac{\sin w}{\cos w} + m\, m', \text{ or } \frac{\sin w}{\cos w} = \tan w = \frac{1 - m\, m'}{2m},$$

which gives for the known coefficients m and m', the frictional angles w and w' of the beam which is the maximum at which it can be set without sliding.

FRICTION ON INCLINED PLANE.

A load q rests on an inclined plane, which has an angle against the horizontal $= w$ (Fig. 37). A force P is exerted to prevent the body from sliding; the force P' is required to keep the body at rest while force P may be so large as to pull the body up. P'' is the force which in this case must be exerted in opposite direction to force P to counteract this pull.

[redacted]

Force parallel to the plane (Fig. 38).

$$P = Q\ (sin\ u + m\ cos\ w) = Q\frac{sin\ (w + e)}{cos\ e}.$$

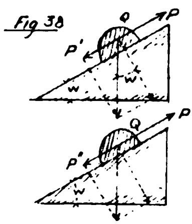
$$P' = Q\ (sin\ w - m\ cos\ w) = Q\ sin\ (w - e).$$

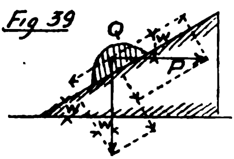
$$P'' = Q\ (m\ cos\ w - sin\ w) = Q\frac{sin\ (w - e)}{cos\ e}.$$

Q the weight of the body; therefore, the force to be considered in calculating the friction is its vertical component to the plane $= Q\ cos\ w$, and the force tending to slide the weight in the direction of the plane is the other component of Q in this direction $= Q\ sin\ w$. We have

$P = m\ Q\ cos\ w + Q\ sin\ w =$ friction + sliding force of Q.

Introducing the angle e, we know that when equilibrium is to





Force Parallel to Plane. Force Parallel to Base.

Friction on Inclined Plane.

exist, the friction must be equal to the sliding component of load Q. Hence, $m\ Q\ cos\ w = Q\ sin\ w$. But this is the condition when the angle is called friction angle, and $= e$. Hence

$$m\ Q\ cos\ w = m\ Q\ cos\ e = Q\ sin\ e;$$

and

$$m = \frac{sin\ e}{cos\ e} = tan\ e,$$

and

$$Q\ (sin\ w + tan\ e \times cos\ w) = P,$$

which can be written

$$Q\ (sin\ w + \frac{sin\ e}{cos\ e}\ cos\ w) = P;\ \text{or,}\ Q\frac{sin\ w\ cos\ e + cos\ w\ sin\ e}{cos\ e},$$

and this expression in parenthesis is the sine of the sum of the two angles $= sin\ (w + e)$. Therefore,

$$P = Q \frac{\sin (w + e)}{\cos e},$$

and so on for P' and P''.

P'' is evidently the difference between the friction and the sliding force of the body.

Force parallel to the base (Fig. 39).

$$P = Q \frac{\sin w + m \cos w}{\cos w - m \sin w} = Q \tan (w + e).$$

$$P' = Q \frac{\sin w - m \cos w}{\cos w + m \sin w} = Q \tan (w - c).$$

$$P'' = Q \tan (e - w).$$

The above formulæ are obtained as follows: Resolve forces P and Q into components in the direction of, and vertical to, the plane, the two vertical components $Q \cos w$ and $P \sin w$ are evidently the total vertical force. The friction, therefore $= m$ $(Q \cos w + P \sin w)$. The other two components tend to move the body along the plane and are $= Q \sin w$ and $P \cos w$. The friction + the moving component of Q must be equal to the moving component of P. Therefore,

$$P \cos w = Q \sin w + m \ (Q \cos w + P \sin w),$$

or

$$P \ (\cos w - m \sin w) = Q \ (\sin w + m \cos w),$$

and

$$P = Q \frac{\sin w + m \cos w}{\cos w - m \sin w},$$

as stated above.

To determine P' the friction must be considered opposed to P' instead of assisting, as was the case with force P; therefore,

$$P' \cos w = Q \sin w - m \ (Q \cos w - P \sin w).$$

$$P' \ (\cos w - m \sin w) = Q \ (\sin w - m \cos w).$$

$$P' = Q \frac{\sin w - m \cos w}{\cos w + m \sin w},$$

and for P'' the force must be the friction less the moving component of Q; or, the reverse of the value for P. P was $= \tan$ $(w + e)$; *therefore*, $P'' = \tan \ (e - w)$. If, as in Fig. 40, the force is directed at an angle to the inclined plane $= w'$, draw the *force diagram for* P and Q, then the total force against the *plane is* $= Q \cos w - P \sin w'$ and the friction $= m$ $(Q \cos w$

[redacted]

— $P \sin w'$), and the total amount of moving forces (friction included),

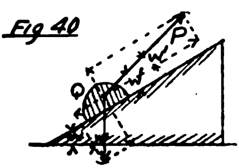
$$P \cos w' = Q \sin w + m\,(Q \cos w - P \sin w').$$

$$P = Q\,\frac{(\sin w + m \cos w)}{\cos w' + m \sin w'} = Q\,\frac{\sin (w + e)}{\cos (w' - e)}.$$

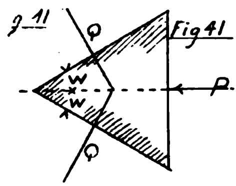
$$P' = Q\,\frac{\sin w - m \cos w}{\cos w' - m \sin w'} = Q\,\frac{\sin (w - e)}{\cos (w' + e)}.$$

FRICTION OF THE KEY.

If Q is the resistance of the sides of the slot against the tapering sides of the wedge in Fig. 41, w = the one-half angle of the



Force at an Angle to Plane.
Friction on Inclined Plane.



Friction of the Key.
For Square Thread.

wedge, P = power to drive the wedge, P' = the force which prevents the wedge slipping back, and P'' the power to draw the wedge out, we have

$$P = 2Q\,(\sin w + m \cos w).$$

$$P = 2Q\,\frac{\sin (w + e)}{\cos e}.$$

$$P' = 2Q\,(\sin w - m \cos w).$$

$$P'' = 2Q\,(m \cos w - \sin w).$$

FRICTION OF SCREW.

Q the force exerted in the direction of the axis of the screw; h = pitch; r = mean diameter of screw; R = crank radius; P = force required to tighten the screw; P' the force required to prevent the screw from backing; P'' = the force required to loosen the screw after having been tightened.

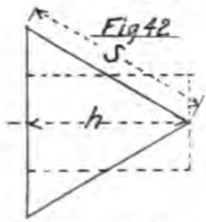
Square Thread.

$$P = Q\,\frac{r\,(h + 2\,m\,r\,\pi)}{R\,(2\,r\,\pi - m\,h)};$$

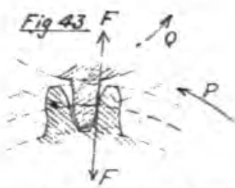
$$P' = Q \frac{r\,(h - 2\,m\,r\,\pi)}{R\,(2\,r\,\pi + m\,h)},$$

$$P'' = Q \frac{r\,(2\,m\,r\,\pi - h)}{R\,(2\,r\,\pi + m\,h)}.$$

For sharp cornered thread we have to use another coefficient m' in the above formula, and this coefficient is found by multiplying m with the quotient formed by the one long side of the triangle forming the V thread to its height (which is the bearing surface of the flat thread) $= nm$. It is evident that a flat thread has a smaller frictional surface than the V-shaped, as the side is longer than the height of the triangle (Fig. 42).



Friction of the Key.
For Sharp Cornered Thread.



Friction of Spur Gear.

Having found factor n, we replace, in the above formula, m by nm, and then the formula is correct for the V-shaped thread.

FRICTION OF SPUR GEARS.

If Q = load (Fig. 43) transferred to pitch line of the driven gear, and P the force exerted at the pitch line of the driving gear n and n'' the respective number of teeth, we have

$$P = Q + m\,\pi\,Q\left(\frac{1}{n'} + \frac{1}{n''}\right).$$

The friction between two gears is proportional to the length of the working way of each tooth and the number of teeth.

Rack and Gear.—Here n'' = infinite, therefore

$$P = Q + \frac{m\,\pi\,Q}{n'}.$$

If the pinion is working inside of the spur wheel, n'' is negative, hence

$$P = Q + m\,\pi\,Q\left(\frac{1}{n'} - \frac{1}{n''}\right).$$

If there are more than two gears working in each other and their respective numbers of teeth are n', n'', and n_1', n_1'', and n_2', n_2'', and p is $=$ the force which counteracts Q without friction (see equilibrium of gears), then, including the friction, we have

$$P = p\left(1 + m\,\pi\left(\frac{1}{n'} + \frac{1}{n''} + \frac{1}{n_1'} + \frac{1}{n_1''}\ldots\right)\right)$$

FRICTION OF BEVEL GEAR.

In addition to the letters used before we make the angle formed by the two axes of the two gears $= w$ in Fig. 44.

$$P = Q + m\,\pi\,Q\sqrt{\frac{1}{n'^2} + \frac{1}{n''^2} + \frac{2\cos w}{n'\,n''}}.$$

Friction between worm and worm wheel.—Q is the load transferred to the pitch line of the worm wheel; r = radius of pitch line of worm; R = radius of crank; P = force necessary to turn the worm; P' = force necessary to apply to the crank to allow the worm wheel to move back; h = pitch of worm, then

$$P = Q\,\frac{r\,(h + 2\,m\,r\,\pi)}{R\,(2\,r\,\pi - m\,h)},$$

$$P' = Q\,\frac{r\,(h + 2\,m\,r\,\pi)}{R\,(2\,r\,\pi + m\,h)}.$$

These formulas are correct when the friction of the teeth is neglected, but we can do so, because the motion of the teeth is very small in comparison with the motion of the threads of the worm. If we want to take account of it, we must multiply the amounts of P and P' with the factor $\left(1 + \dfrac{m\,\pi}{n}\right)$.

ROPE FRICTION.

If a *rope passes* over a cylinder which cannot turn (Fig. 45)

the rope rests upon a part of the cylinder = to the arc of the angle w, expressed in parts of r. If Q is the load, then

$P = Q\ e^{mw}$ (e = *basis of hyperbolic logarithm* = 2.71828).

If the rope rests on a beam shaped as shown,

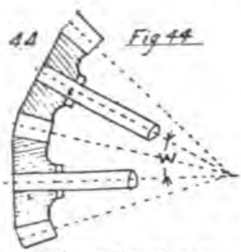
$$P = Q\left(1 + 2\,m\,\sin\frac{w}{2}\right).$$

If the rope passes over more corners (Fig. 46), we have to add the factor $\left(1 + 2\,m\,\sin\frac{w'}{2}\right)$; w' being the new angle; and so on for each corner the rope makes. Therefore, for n corners, all having the same angle,

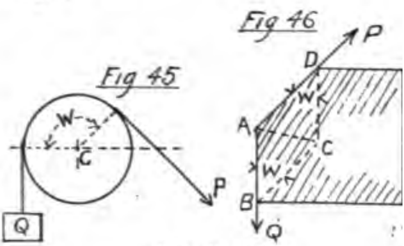
$$P = Q\left(1 + 2\,m\,\sin\frac{w}{2n}\right)^{n}.$$

and if the force is to be equal to the friction

$$P' = \frac{Q}{e^{mw}} = Qe^{-mw}.$$



Friction of Bevel Gear.



Rope Friction.

JOURNAL FRICTION.

Journals of wrought or cast iron in iron bearings lubricated with grease have $m = 0.054$ if the greasing is done continually,

$m = 0.07$ to 0.09 if greased at intervals.

For wooden journals and bearings m is about double the amount.

Horizontal Journals.—A shaft has two bearings, and secured to the shaft is a rope wheel to which P is attached by means of a rope; the diameter of the pulley is $= 2R$; a drum which by means of a rope lifts load Q is also provided on the shaft; i

[redacted]

diameter is $2r$. Q = the load + the weight of the shaft with attachments; r' = radius of the journal; S = vertical force against the journal.

$$P\,R = Q\,r + m\,S\,r'.$$

S = journal pressure, depends upon the forces, the weight of the shaft and attachments, and the direction of the forces.

1.) P, Q and G (weight of shaft and attachments) are directed vertically.

$$S = P + Q + G.$$

$$P = \frac{Q\,r + m\,(Q+G)\,r'}{R - m\,r'}.$$

2.) Q and G are vertical, and P vertical and upwards:

$$S = Q + G - P.$$

$$P = \frac{Q\,r + m\,(Q+G)\,r'}{R + m\,r'}.$$

3.) Q and G have the same direction, but P is directed vertically to both:

$$S = \sqrt{(Q+G)^2 + P^2}.$$

If $(Q+G) > P$ then, approximately,

$$S = 0.96\,(Q+G) + 0.40\,P, \text{ and}$$

$$P = \frac{Q\,r + 0.96\,m\,(Q+G)\,r'}{R - 0.40\,m\,r'}.$$

if

$$P < \tfrac{1}{6}\,(G+Q),$$

and

$$S = Q + G,$$

$$P = \frac{Q\,r + m\,(Q+G)\,r'}{R}.$$

If P acts on a crank, S is variable, and as a mean value $S = Q + G$, may be taken.

Journal Friction of Rope Pulley.—If we neglect the weight of it, which is small, and call r the radius of the pulley, and P and Q the forces, we have:

1.) P and Q are parallel:

$$P = Q\,\frac{r + m\,r'}{r - m\,r'},$$

approximately,

$$P = Q\left(1 + \frac{2\,m\,r'}{r}\right).$$

$$S = P + Q.$$

2.) P and Q vertical to each other:

$$S = \sqrt{P^2 + Q^2},$$

or approximately

$$S = Q\sqrt{2}$$

as P and Q can not differ much in amount. Therefore,

$$P = Q\left(1 + \frac{m\,r'\sqrt{2}}{r}\right).$$

Journal Friction of Block and Fall.—We have a common block and fall with n pulleys; the radius of each is $= r'$, then coefficient of friction $M = 1 + \frac{2\,m\,r'}{r}$, found before.

$$P = \frac{Q\,M^n\,(M-1)}{M^n - 1},$$

and for $n = 2$.

$$P = \tfrac{1}{2}\,Q\left(1 + \frac{3\,m\,r'}{r}\right).$$

It is evident from the equation

$$P = \frac{Q\,M^n\,(M-1)}{M^n - 1},$$

that P must be always smaller than $Q\,(M-1)$ no matter how many pulleys are used. This means that too large a number of pulleys is not advisable.

If we take $r' : r = 1 : 6$ and $m = 0.15$, because these pulleys will seldom be lubricated, we have

$$M = 1 + 2\,m\frac{r'}{r} = 1.05,$$

and for different numbers of n:

$n = 2$	$P = 0.54\ Q$	$P > \tfrac{1}{2}\,Q.$
$n = 4$	$P = 0.28\ Q$	$P > \tfrac{1}{4}\,Q.$
$n = 6$	$P = 0.20\ Q$	$P = \tfrac{1}{5}\,Q.$
$n = 8$	$P = 0.155\ Q$	$P >$ [illegible] Q

Bottom Friction of Upright Shaft.—Radius of bearing face $= r'$; $P =$ force on crank of radius R. The loss of power $=$ static moment $= \frac{2}{3}\, m\, Q\, r'$ (friction loss).

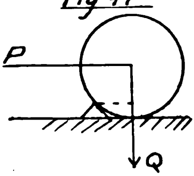
If the face of the shaft is not flat, but rounded, the friction is increased, and if it is a half globe it is $= \frac{1}{2}\, m\, \pi\, Q\, r'$.

ROLLING FRICTION.

1. The frictional resistance is proportional to the vertical force against the bearing.
2. The frictional resistance is inversely proportional to the radius of the rolling cylinder.

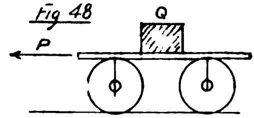
$v =$ coefficient of rolling friction. For rollers of lignum vitæ, rolling on oak planks, $v = 0.046$; for rollers of elm wood, rolling on oak planks, $v = 0.08$; for cast-iron on rails, $v = 0.05$.

Fig 47



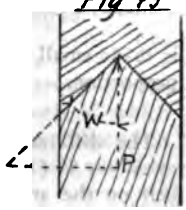
Rolling Friction.

Fig 48



Double Rolling Friction.

Fig 49



Conical Friction Wheels.

This rolling friction (Fig. 47) must be considered as a stumbling of the roller. The roughness of the rolling surface causes the roller to stop and to climb the projection, and since the point of contact stands still, the roller will turn around this fulcrum, and the moment of this motion $= v\, Q$ (v to be taken in the same unit as r); $P = v\,\frac{Q}{r}$.

Double Rolling Friction.—A load is moved by means of two free rollers (Fig. 48) supporting the load either directly or by means of an intervening board. The force is exerted at, and in the direction of, the board, and the respective friction coefficients are $= m$ and m'. Then

$$P = \frac{v + v'}{2\, r}\, Q.$$

The rolling frictional resistance is used in several cases:

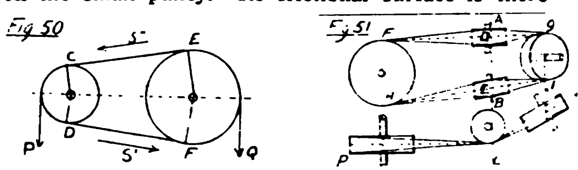
Friction Wheels.—Two cylinders are forced against each other by the force $= K$. The force P which can be transmitted from one to the other is $= P = m\,K$, or $K = \frac{1}{m} P$.

These friction wheels should not be used except where a small force only is to be transmitted, but smooth action is required, as the friction in the journals is considerable.

Conical Friction Wheels.—In order to reduce the journal friction, and still to transfer considerable power from one wheel to the other, the face of the one wheel is v-shaped, and the other has a recess to suit (Fig. 49). $K =$ pressure with which the axes are pressed together; $w = \frac{1}{2}$ of the angle of the wedge, or v-shape; $P =$ force to be transmitted. $P = \frac{m\,K}{\sin w}$. If angle w is made small, the sine will decrease, and therefore, P increase in proportion.

FRICTION OF BELTS ON PULLEYS.

The difference of the tensions of the upper and lower belt $= S'' - S'$ (Fig. 50) must be not more than the friction of the belt on the small pulley. Its frictional surface is there $=$ *arc*



Friction of Belts and Pulleys.

$CD = w$ (expressed in part of r); $K =$ the tension between the two axes, and $S' + S'' = K$.

$$S'' - S' = K\,\frac{e^{wm} - 1}{e^{mw} + 1}.$$

The journal friction in case of belts is a little greater than with gears, but much less than with friction wheels.

Open belts give less belt friction than crossed ones. If r' and r'' are the respective radii of the two pulleys, and $d =$ distance *between the centers* of their shafts, then for open belts:

$$\cos\frac{w}{2} = \frac{r'' - r'}{d},$$

and for crossed belts

$$\cos\frac{w}{2} = \frac{r'' + r'}{d}.$$

If the belt pulleys are not in the same plane (Fig. 51), then find point L, the crossing point in the plane of the centers of both pulleys, center lines representing planes. AB represents, in the elevation, the intersecting line of these two planes. Now select two points B and E of AB, but so that the belts are supported, and draw tangents from them: AG, JE and AF, HE. These represent the belt lines in the elevation.

$m = 0.50$ for hemp rope on wood pulleys, and for new belts.
$m = 0.47$ for ordinary greasy belts on wood pulleys.
$m = 0.38$ for moist belts on turned cast-iron pulleys.
$m = 0.12$ for greased belts on turned cast-iron pulleys.

FRICTION ROLLER BEARING.

If the journal A rests, instead of on a solid bearing, on the peripheries of two rollers, as shown in Fig. 52, both of which have a radius $= R$ and a journal radius of r, and are placed at the distance d from center to center, then $S =$ journal pressure at A and moment of friction $= \dfrac{m\,S\,r'\,r}{R}$.

If d is small as compared with $R + r'$, then the pressure upon the journals of each roller $= \frac{1}{2}\,S$, or the friction $= \frac{1}{2}\,m\,S$, and the force necessary to overcome this at the peripheries of the rollers $= \dfrac{m \cdot S\,r}{2\,R}$. Therefore, both rollers offer a resistance of $\dfrac{m\,S\,r}{R}$, and the moment of friction $= \dfrac{m\,S\,r}{R}\,r'$.

This moment of friction for a solid bearing is $= m\,S\,r'$, and it is evident that the additional factor in the equation for the roller bearing $= \dfrac{r}{2\,R}$, makes the friction much less.

WAGONS.

The load Q is to be moved upon the level ground. $R =$ radius of the wheels; $r =$ radius of the axles, and m and v the coefficients of the journal, and rolling friction. Then

$$P = \frac{Q}{R}(m\,r + v).$$

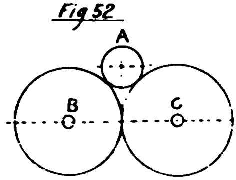
The value of Q must, of course, include the weight of the wagon.

This formula shows that, other conditions being equal, the force to be exerted will be smaller when the axles are smaller and the wheels are larger.

If we combine the two frictions m and v into one factor V we have its values as follows:

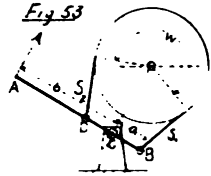
For very good macadam, dry and smooth	$\frac{1}{50}$	to	$\frac{1}{65}$
For hard macadam with light ruts	$\frac{1}{37}$	to	$\frac{1}{48}$
For bad macadam with 2.4" ruts	$\frac{1}{13}$	to	$\frac{1}{21}$
For good granite pavement	$\frac{1}{65}$	to	$\frac{1}{105}$
For medium granite pavement and moist dirt	$\frac{1}{46}$	to	$\frac{1}{78}$
For solid natural ground	$\frac{1}{27}$	to	$\frac{1}{45}$
For solid natural ground with ½" gravel	$\frac{1}{10}$	to	$\frac{1}{17}$
For smooth plank road	$\frac{1}{43}$	to	$\frac{1}{71}$
For Railroad tracks	$\frac{1}{250}$	to	$\frac{1}{370}$

Fig 52



Friction Roller Bearing.

Fig 53



Band Brake.

The smaller values were obtained with wagons having 4' wheels, and the larger values with wheels having 7' diameter.

BRAKES.

To prevent a wagon from going down an incline with undesirable speed, a piece of wood is forced against the rim of the wheel, the force exerted $= Q$. The wheel will then not turn, but slide along the ground. Therefore, the total friction $= (m - m')\,Q$; $m' =$ friction coefficient between block and rim; $K =$ force exerted against the rim of the wheel. $m'\,K$ must be larger than the force which is exerted on the rim. Neglecting *the axle friction* we have the value $= m\,Q$, and the friction *therefore* $K > \frac{m}{m'}Q$.

The Band Brake.—A lever pivoted at C (Fig. 53) and attacked by force P at A, receives the two ends of an iron band at D and B. The band circles a pulley which is to be prevented from turning. $w =$ arc of wheel touched by the band, expressed in parts of r; the lever arms are $a = CB$ and $b = AC$. Then the frictional moment is $= P \dfrac{b\,(e^{wm} - 1)}{a}$.

ROPE STIFFNESS.

The stiffness of a rope is the resistance caused by the friction between the strands against each other, when the rope is bent. This friction is approximately proportional to the tension Q, the square of the diameter $= d$ of the rope, and inversely proportional to the diameter of the radius around which it is bent. $r =$ this radius, and $S =$ rope stiffness.

$$S = x \frac{Q\,d^2}{r},$$

$x =$ coefficient of rope stiffness.

If we express d and r in inches, then $x = \frac{1}{8}$.

ROPE STIFFNESS IN THE CASE OF BLOCK AND FALL.

A common block and fall has n pulleys of $r =$ radius and $r' =$ journal radius, $d =$ diameter of rope.

$$m = \left(1 + \frac{2\,m\,r'}{r} + \frac{d^2}{5\,r}\right).$$

$$P = \frac{Q\,m^n\,(m - 1)}{m^n - 1}.$$

If we assume that $d = 1$, and $r = 5$, the following table will give the efficiency of blocks and falls with different numbers of pulleys superseding the table given before which did not allow for the rope stiffness:

$n = 2$	$P = 0.615\,Q$	$P > \frac{3}{5}\,Q$.
$n = 4$	$P = 0.35\,Q$	$P > \frac{1}{3}\,Q$.
$n = 6$	$P = 0.26\,Q$	$P > \frac{1}{4}\,Q$.
$n = 8$	$P = 0.22\,Q$	$P > \frac{1}{5}\,Q$.

POWER.

ELEMENTARY STANDARDS AND MEASURES FOR STEAM ENGINES AND BOILERS.

Evaporative efficiency of a boiler is the quotient formed by dividing that part of the total heat of one pound of fuel, which is used to heat and to evaporate one pound of water, by the total heat of the fuel itself.

The usual measure for Boiler Capacity is H.-P., read "horse-power," which is, strictly speaking, inaccurate, because H.-P. is a measure of power only. When the capacity of a boiler is spoken of, this H.-P. must be called *Boiler Horse-power,* and such a H.-P. is the capacity of a boiler to heat 30 pounds of water from 100° to 212° F., and to evaporate 30 pounds of water of 100° F. per hour to steam at 70 pounds pressure per square inch, or 34.5 pounds of water evaporated from and at 212° F.

Work consists of the sustained exertion of pressure through space. The unit of work is one foot-pound, or the pressure of one pound sustained through a space of one foot.

Horse-power (H.-P.) is the measure of rate at which work is performed.

1,980,000 foot-pounds per hour = one H.-P.
33,000 foot-pounds per minute = one H.-P.
550 foot-pounds per second = one H.-P.

Duty Work is the quotient obtained by dividing the number of foot-pounds per hour by the amount of coal used per hour per horse-power. If, for instance, 2.5 pounds of coal are used per hour per horse-power, the duty work is 792,000 foot-pounds.

MEASURES OF PRESSURE AND WEIGHT.

One pound per square inch = 2.309 feet of water at 62° = 2.0416 inches of mercury at 62°.

One atmosphere = 14.7 pounds per square inch = 33.947 feet of water at 62° = 30 inches of mercury at 62°.

One foot of water at 62° = 0.433 pounds per square inch = 62.355 pounds per square foot = 0.883 inches of mercury at 62°.

One inch of mercury at 62° = 0.49 pounds per square inch = 70.56 pounds per square foot = 14 inches of water at 62°.

WATER.

One cubic foot of pure water:

At 32° (freezing point) weighs 62.418 pounds.
At 39.1° (maximum density) weighs 62.425 pounds.
At 62° (standard temperature) weighs 62.355 pounds.
At 212° (boiling point of water) = 59.640 pounds.

Average weight of one cubic foot of water = 62.33 pounds.

One gallon of water at 62° = 8.313 pounds.
One gallon of water at 62° contains 231 cubic inches.
One cubic foot of water contains 7.5 gallons.
One standard barrel contains 31½ gallons.
One beer barrel contains 31 gallons.
One standard barrel of water weighs 262.5 pounds.
One beer barrel of water weighs 258.5 pounds.

The specific heat of ice is 0.5; of gaseous steam, 0.62, taking water as the unit.

A *Heat-unit,* or *thermal unit,* is the quantity of heat necessary to raise the temperature of one pound of water one degree.

One thermal unit (th. u.) = 778 foot-pounds (772 according to Joule).

STEAM.

"Saturated" steam is steam which is, or has been, in contact with water and has not been heated or compressed. Expansion or cooling will cause condensation, and then the steam is certainly saturated. For every temperature of saturated steam there is only one pressure possible, and for each pressure only one temperature.

"Superheated" Steam.—The superheating of saturated steam occurs when the same is compressed without abstraction of heat, or is heated directly. In order to understand its nature, pressure and temperature must be given.

TOTAL HEAT OF EVAPORATION.

The total heat of evaporation consists of:

Sensible heat necessary to raise the temperature of one pound of water from 32° to 212° .... = 180.9 th. u.

Latent heat to evaporate one pound of water at 212° .... = 892.935 th. u.

Heat of discharge required to overcome the pressure of the atmosphere resisting the escape of the vapor .... = 72.865 th. u.

1146.7 th. u.

Specific heat of saturated steam = 0.305.

Saturated steam heated from 212° to 230° acts, when further heated or compressed, like a permanent gas.

MOTION OF STEAM.

Steam leaving a vessel and entering another vessel at lower pressure will flow out quicker in proportion to the difference between the absolute pressure. The limit is reached at 58 per cent when the steam, even if discharged into a vacuum, will neither increase nor decrease its velocity.

TABLE SHOWING THE AMOUNT OF STEAM, ETC., LEAVING A BOILER AT 75 POUNDS' PRESSURE AND ENTERING ANOTHER VESSEL AT VARYING PRESSURES.

Absolute Pressure in Boiler.	Absolute Exhaust Pressure.	Ratio Expansion at Nozzle.	Velocity of Outflow at Constant Density, Feet per Second.	Actual Velocity of Outflow, Expanded Steam, Feet per Second.	Discharge per Square Inch Orifice per Minute, Pounds.
75	74.	1.012	227.5	230.	16.68
75	72.	1.037	326.7	401.	28.35
75	70.	1.063	490.0	521.	35.93
75	65.	1.136	660.0	749.	48.38
75	61.62	1.198	736.	876.	53.97
75	60.	1.219	765.	933.	56.12
75	50.	1.434	873.	1252.	64.00
75	45.	1.575	890.	1401.	65.24
75	per cent { 43.46 / 58 }	1.624	890.6	1446.5	65.30
75	15.	1.624	890.6	1446.5	65.30
75	0.	1.624	890.6	1446.5	65.30

Approximate velocity of steam figured at same density is 900 feet per second.

TABLE OF PROPERTIES OF SATURATED STEAM.

Gauge Pressure Per Sq. Inch in Pounds.	Pressure Above Vacuum Per Sq. Inch in Pounds.	Temperature in Degrees Fahrenheit.	Total Heat in Heat Units at 32° F.	Heat in Liquid from 32° in Heat Units.	Heat of Vaporization or Latent Heat in Heat Units.	Density or Weight of 1 Cubic Foot in Pounds.	Volume of one Pound in Cubic Feet.	Factor of Equivalent Evaporation at 212° Fahrenheit.
......	1	101.99	1113.1	70.0	1043.0	0.00299	334.50	0.9661
......	2	126.27	1120.5	94.4	1026.1	0.00576	173.60	0.9738
......	3	141.62	1125.1	109.8	1015.3	0.00844	118.50	0.9786
......	4	153.09	1128.6	121.4	1007.2	0.01107	90.33	0.9822
......	5	162.34	1131.5	130.7	1000.8	0.01366	73.21	0.9852
......	6	170.14	1133.8	138.6	995.2	0.01622	61.65	0.9876
......	7	176.80	1135.9	145.4	990.5	0.01874	53.39	0.9897
......	8	182.92	1137.7	151.5	986.2	0.02125	47.06	0.9916
......	9	188.33	1139.4	156.9	982.5	0.02374	42.12	0.9934
......	10	193.25	1140.9	161.9	979.0	0.02621	38.15	0.9949
0.0	14.7	212.00	1146.6	180.7	966.0	0.03793	26.78	1.0000
0.03	15	213.03	1146.9	181.8	965.1	0.03826	26.14	1.0003
5.3	20	227.95	1151.5	196.9	954.6	0.05023	19.91	1.0051
10.3	25	240.04	1155.1	209.1	946.0	0.06199	16.13	1.0099
15.3	30	250.27	1158.3	219.4	938.9	0.07360	13.59	1.0129
20.3	35	259.19	1161.0	228.4	932.6	0.08508	11.75	1.0157
25.3	40	267.13	1163.4	236.4	927.0	0.09644	10.37	1.0182
30.3	45	274.29	1165.6	243.6	922.0	0.1077	9.285	1.0205
35.3	50	280.85	1167.6	250.2	917.4	0.1188	8.418	1.0225
40.3	55	286.89	1179.4	256.3	913.1	0.1299	7.698	1.0245
45.3	60	292.51	1171.2	261.9	909.3	0.1409	7.097	1.0263
50.3	65	297.77	1172.7	267.2	905.9	0.1519	6.583	1.0280
55.3	70	302.71	1174.3	272.2	902.1	0.1628	6.143	1.0295
60.3	75	307.38	1175.7	276.9	898.8	0.1736	5.760	1.0309
65.3	80	311.80	1177.0	281.4	895.6	0.1843	5.426	1.0323
70.3	85	316.02	1178.3	285.8	892.5	0.1951	5.126	1.0337
75.3	90	320.04	1179.6	290.0	889.6	0.2058	4.859	1.0350
80.3	95	323.89	1180.7	294.0	886.7	0.2165	4.619	1.0362
85.3	100	327.58	1181.9	297.9	884.0	0.2271	4.403	1.0374
90.3	105	331.13	1182.9	301.6	881.3	0.2378	4.205	1.0385
95.3	110	334.56	1184.0	305.2	878.8	0.2484	4.026	1.0396
100.3	115	337.86	1185.0	308.7	876.3	0.2589	3.862	1.0406
105.3	120	341.05	1186.0	312.0	874.0	0.2695	3.711	1.0416
110.3	125	344.13	1186.9	315.2	871.7	0.2800	3.571	1.0426
115.3	130	347.12	1187.8	318.4	869.4	0.2904	3.444	1.0435
125.3	140	352.85	1189.5	324.4	865.1	0.3113	3.212	1.0453
135.3	150	358.26	1191.2	330.0	861.2	0.3321	3.011	1.0470
145.3	160	363.40	1192.8	335.4	857.4	0.3530	2.833	1.0486
155.3	170	368.29	1194.3	340.5	853.8	0.3737	2.676	1.0502
165.3	180	372.07	1195.7	345.4	850.3	0.3945	2.535	1.0517
175.3	190	377.44	1197.1	350.1	847.0	0.4153	2.408	1.0531
185.3	200	381.73	1198.4	354.6	843.8	0.4359	2.294	1.0545
210.3	225	391.79	1201.4	365.1	836.3	0.4876	2.051	1.0576
235.3	250	400.99	1204.2	374.7	829.5	0.5393	1.854	1.0605
260.3	275	409.50	1206.8	383.6	823.2	0.5913	1.691	1.0632
285.3	300	417.42	1209.3	391.9	817.4	0.644	1.553	1.0657
310.3	325	424.82	1211.5	399.6	811.9	0.696	1.437	1.0680
335.3	350	431.90	1213.7	406.9	806.8	0.728	1.337	1.0703
360.3	375	438.40	1215.7	414.2	801.5	0.800	1.250	1.0724
385.3	400	445.15	1217.7	421.4	796.3	0.853	1.172	1.0745
485.3	*500*	*466.57*	1224.2	414.3	779.9	1.065	0.939	1.0812

See also pages 292, 293.

OUTFLOW OF STEAM INTO THE ATMOSPHERE

Absolute Initial Pressure per sq. in.	Velocity of Outflow as at Constant Density.	Actual Velocity of Outflow Expanded.	Discharge per sq. in. of Orifice per minute.	Horse-power per sq. in. of Orifice if H. P. = 30 lbs. per hour.
lbs.	Feet per second.	Feet per second.	lbs.	H. P.
25.37	863	1401	22.81	45.6
30	867	1408	26.64	53.7
40	874	1419	35.18	70.4
50	880	1429	44.06	88.1
60	885	1437	52.50	105.2
70	889	1444	61.07	122.1
75	891	1447	65.30	130.6
90	895	1454	77.94	155.9
100	898	1459	86.34	172.7
115	902	1466	98.76	197.5

External pressure per sq. inch 14.7 lbs. Ratio of expansion in nozzle 1.624.

COMBUSTION.

The combustible elements of fuel are carbon, hydrogen and sulphur. The oxygen of the atmosphere is consumed by them in the process of combustion and oxidizes the elements, while the nitrogen is neutral.

The elements which make up the atmospheric air are only mechanically mixed, the ratio being eight weight units of oxygen to 26.8 weight units of nitrogen, or one pound of oxygen to 3.35 pounds of nitrogen, or 23 per cent oxygen and 77 per cent nitrogen.

Elements.	Process.	Product.
	COMBUSTION OF HYDROGEN.	
1 pound of hydrogen	Hydrogen... 1 pound.	9 pounds of water.
34.8 pounds of air.......	Oxygen..... 8 pounds.	
	Nitrogen.... 26.8 pounds.	26.8 lbs. of nitrogen.
35.8 pounds	35.8 pounds.	35.8 pounds.
	COMPLETE COMBUSTION OF CARBON.	
1 pound of carbon.....	Carbon...... 1 pound.	3.66 pounds carbonic acid.
11.6 pounds of air........	Oxygen..... 2.66 pounds.	
	Nitrogen.... 8.94 pounds.	8.94 pounds nitrogen.
12.6	12.6	12.6
	COMBUSTION OF SULPHUR.	
1 pound of sulphur....	Sulphur......1 pound.	2 lbs. sulphur. acid.
4.35 pounds of air........	Oxygen......1 pound.	
	Nitrogen.....3.35 pounds.	3.35 pounds nitrogen.
5.35	5.35	5.35

VOLUME OF ONE POUND OF GAS CONCERNED IN OR ABOUT COMBUSTION AT 62° UNDER PRESSURE OF ONE ATMOSPHERE.

Gas at 62°.	Cubic Feet.	Specific Heat at Constant Pressure.
Oxygen	11.887	0.2182
Hydrogen	190.000	3 4046
Nitrogen	13.501	0.244
Air (atmospheric)	13.141	0.237
Carbonic acid	8.594	0.2164
Gaseous steam	21.125	0.475
Sulphurous acid	5.848	0.1553

The proportion of elements is: One cubic foot of oxygen to 3.76 cubic feet of nitrogen, or 21 per cent by volume of oxygen to 79 per cent by volume of nitrogen.

Every pound of oxygen consumed in combustion requires a supply of 4.35 pounds or 57.16 cubic feet of air.

Every cubic foot of oxygen consumed in combustion requires a supply of 4.76 cubic feet of air.

QUANTITIES OF AIR REQUIRED FOR THE COMBUSTION OF ONE POUND.

One Pound of	Air at 62°.	Products.
Hydrogen	34.8 pounds or 457 cubic feet	Water.
Carbon completely burned.	11.6 pounds or 152 cubic feet	Carbonic acid.
Carbon incompletely burned	5.8 pounds or 76 cubic feet	Carbon monoxide.
Sulphur	4.35 pounds or 57 cubic feet	Sulphurous acid.

To find the quantity of air at 62° and at 30" atmospheric pressure, that is chemically consumed in the complete combustion of one pound of fuel of given composition, call the weight per cents of each : oxygen O, sulphur S, nitrogen N, hydrogen H, carbon C. Then the amount expressed in cubic feet of air is:

$$(C + 3H - 0.4\,O)\ 1.52 \text{ cu. ft. of air,}$$

or

$$\frac{C + 3H - 0.4\,O}{13.14}\ 1.52 = \text{pounds of air.}$$

The total weight of the gaseous products of the complete combustion of one pound of fuel:

$$lbs.\ gas = 0.126\,C + 0.358\,H,$$

or in cubic feet

$$\text{cu. ft. } gas = 1.52\,C + 5.52\,H.$$

The volumes for other temperatures than 62°, if V = volum

at 60°, V' the volume at the desired temperature, and t' the desired temperature, are

$$V' = V \frac{t' + 461}{523}.$$

FLOW OF STEAM THROUGH PIPES.

Initial Pressure by Gauge, Lb. Per Sq. In.	Diameter of Pipe in Inches. Length of Each=240 Diameters.													
	¾	1	1½	2	2½	3	4	5	6	8	10	12	15	18
	Weight of Steam Per Minute in Pounds, With 1 Pound Loss of Pressure.													
1	1.16	2.07	5.7	10.27	15.45	25.38	46.85	77.3	115.9	211.4	341.1	502.4	804	1177
10	1.44	2.57	7.1	12.72	19.15	31.45	58.05	96.8	143.6	252.0	422.7	622.5	996	1458
20	1.70	3.02	8.3	14.94	22.49	36.94	68.20	112.6	168.7	307.8	496.5	731.3	1170	1713
30	1.91	3.40	9.4	16.84	25.35	41.63	76.84	126.9	190.1	346 8	559.5	824.1	1318	1930
40	2.10	3.74	10 3	18.51	27.87	45.77	84.49	139.5	209.0	381.3	615.3	906.0	1450	2124
50	2.27	4.04	11.2	20.01	30.13	49.48	91.34	150.8	226.0	412.2	665 0	979.5	1567	2292
60	2.43	4.32	11.9	21.38	32.19	52.87	97.60	161.1	241.5	440.5	710.6	1046.7	1675	2451
70	2.57	4.58	12.6	22.65	34 10	56.00	103.37	170.7	255.8	466.5	752.7	1108.5	1774	2596
80	2.71	4.82	13.3	23.82	35.87	58.91	108.74	179.5	269.0	490.7	791.7	1166.1	1866	2731
90	2.83	5.04	13.9	24.92	37.52	61.62	113.74	187.8	281.4	513.3	828.1	1219.8	1951	2856
100	2.95	5.25	14.5	25.96	39.07	64.18	118.47	195.6	293.1	534.6	862.6	1270.1	2032	2975
120	3.16	5.63	15.5	27.85	41.93	68.87	127.12	209.9	314.5	573.7	925.6	1363.3	2181	3193
150	3.45	6.14	17 0	30.37	45.72	75.09	138 61	228.8	343.0	625.5	1009.2	1486.5	2378	3481

FREE AIR IN GASEOUS PRODUCTS.

The weight of the free air which enters the furnace and passes unconsumed, is equal to the volume of the air used chemically, divided by 13.14.

HEAT OF COMBUSTION.

The total amount of heat obtained by the combustion of one pound of the elementary combustibles, by the addition of oxygen, is:

Carbon or charcoal.................14.500 th. u.
Hydrogen ....62.000 th. u.
Sulphur .... 4.000 th. u.

Neglecting the amount of heat required by the sulphur, which is small, we have this heat of combustion $= 145\ (C + 4.28\ H)$ th. u.

Carbon in different forms develops different amounts of heat in combustion.

Wood or charcoal.................14.544 th. u.
Graphite from gas retorts..........14.485 th. u.

Natural graphite. . . . . 14,035 th. u.
Diamonds . . . . 13,986 th. u.

"Approximate Evaporating Power" of one pound of combustible:

For water at $62° = 0.13\ (C + 4.28\ H)$ lbs. of water.
For water at $212° = 0.15\ (C + 4.28\ H)$ lbs. of water.

TEMPERATURE OF COMBUSTION.

The temperature obtained in a boiler furnace is for hydrogen 3,500°, and for carbon 5,000°.

CONDITION FOR COMPLETE COMBUSTION.

Certain conditions are necessary in order to bring about the complete combustion of fuel. The important ones are:

1. Sufficient air;
2. Thorough mixture of fuel and air;
3. Bringing together air and combustible gases at the highest possible temperature.

METHODS OF FIRING BY HAND.

In order to burn the fuel as completely as possible and thus obtain the greatest possible amount of heat from it, attention must be given to feeding the fuel and keeping it in a proper state in the furnace. This is done, in firing by hand, mainly by observing the following points:

1. Spreading the coal evenly over the whole surface;
2. Alternating by filling one-half of the furnace at a time;
3. Coking the fuel by banking it in front, and the next time spreading it and again banking fresh fuel in front.

In slowly burning furnaces with long flues, moistening the fuel before throwing it in, and moistening the ash pit, produces better results from the fuel. The heat radiating upon the ashes produces steam. Steam lessens the "glow fire" or flameless "incandescence" of the fuel, and increases the quantity of the flame by forming carbonic oxide and hydrogen gases in its decomposition into its elements, and the reduction by the oxygen of the carbonic acid already formed in the furnace. The newly made gases are afterward burned in the flues. The presence of moisture even in coke gives rise to a flame in the flues and reduces the intensity of the heat in the glow fire. It aids in distributing combustion over a larger space.

Moist bituminous coal burned in furnaces with long flues is most effective. Under steam boilers coke or coal may be used to equal advantage, but if great heat is required, coke is much more efficient. In a glass furnace the tests have shown that eight or nine pounds of coke was equivalent to twelve pounds of coal, Coke, flameless, is most effective where intensity of heat is needed, or where short flues and rapid draft are to be dealt with.

FUELS.

The fuels used for the production of steam are Coal, Coke, Wood, Peat, Refuse Tan Bark, Straw and Bagasse or Refuse Sugar Cane. Asphalt, Creosote, Oil and Coal Gas are also used as fuels.

COAL.

Coal can be classified as follows:

1. Anthracite, or blind coal, consisting almost entirely of free carbon.
2. Dry Bituminous Coal, having from 70 to 80 per cent of carbon.
3. Bituminous Caking Coal, having from 50 to 60 per cent of carbon.
4. Long Flaming or Cannel Coal, having from 70 to 85 per cent of carbon.
5. Lignite, or Brown Coal, having from 56 to 76 per cent of carbon.

TESTS OF COAL MADE BY THE UNITED STATES NAVY.

	Composition in Percentages of the Total Weight.					
	Moisture Per Cent.	Volatile Matter Other than Moist. Per Cent.	Sulphur Per Cent.	Fixed Carbon Per Cent.	Earthy Matter Per Cent.	Specific Gravity.
Anthracite, Pa..........	1.19	3.97	0.04	88.54	6.28	1.500
Coke, 2 samples from Midlothian and Neffs' Cumberland coal, Va..	......	....	....	....	14.94	......
Free burning bituminous, Md. and Pa......	1.37	15.11	0.42	73.21	10.27	1.358
Bituminous caking, Va..	1.56	29.43	1.01	58.29	10.90	1.342
Foreign and Western bituminous............	2.50	32.68	0.24	57.42	7.85	1.318
Averages of the 3 classes of American coal..................	1.37	16.17	0.49	73.35	9.15	1.400

TESTS OF COAL MADE BY THE UNITED STATES NAVY—(Continued).

	Specific Gravity.	Weight and Bulk.			Coke Produced from Coal. Per Cent.	Ashes and Clinkers Left by Combustion. Per Cent.
		One Cubic Foot Solid Pounds.	One Cubic Foot Heaped Pounds.	Bulk of 1 Ton Heaped Cubic Foot.		
Anthracite, Pa.	1.500	93.78	53.05	42.35	94 82	8.60
Coke, 2 samples from Midlothian and Neff's Cumberland coal, Va.	....	....	32.13	69.76	....	14.94
Free burning bituminous, Md. and Pa.	1.358	84.93	52.84	42.42	83.68	11.27
Bituminous caking, Va.	1.342	83.90	49.28	45.71	69.01	8.48
Foreign and Western bituminous	1.318	82.39	49.31	45.51	65.27	7.98
Averages of the 3 classes of American coal	1.400	87.54	51.72	43.49	82.50	9.42

Anthracite Coal.—The specific gravity varies from 1.35 to 1.92. This coal retains its form when exposed to a temperature of ignition, but when heated too rapidly will fall to pieces. The flame is generally short, and of a bluish yellow color. The coal is ignited with difficulty, and yields an intense local or concentrated heat, and combustion becomes extinct while yet a considerable quantity of the fuel remains on the grate.

Dry Bituminous Coal.—This is a freely burning coal, and lighter than anthracite, its specific gravity varying from 1.28 to 1.44. It contains a relatively small proportion of volatilizable matter, about 15 per cent, and quickly arrives at the temperature of ignition.

It swells considerably in coking, thus facilitating the access of air and the rapid and complete combustion of the fixed carbon. In some cases where combustion is slow, the masses of coke scarcely cohere, and the original forms of the pieces of the coal are in some measure preserved.

Bituminous Caking Coal.—It has the same range of specific gravity as the dry bituminous coal. It contains the maximum proportion of volatilizable matter, averaging about 30 per cent of the whole weight. It develops much of the hydrocarbon gases, and burns with a long flame. It swells considerably and gives a coherent coke, which preserves nothing of the original form of the coal. Its specific heat is 0.20.

TOTAL GASEOUS PRODUCTS AND SURPLUS AIR FOR ONE POUND OF COAL.

Carbonic acid.....	2.93 pounds or 13. %	25.20 cubic feet or 8.7%
Gaseous steam....	0.45 pounds or 2. %	9.51 cubic feet or 3.3%
Oxygen............	2.46 pounds or 10.9%	29.41 cubic feet or 10.2%
Nitrogen	16.73 pounds or 74.1%	225.16 cubic feet or 77.8%
	22.57 100.0%	289.28 100.0%

This shows that if combustion is complete, and the excess of air mixed with the burnt gases is equal to the volume of air chemically consumed, an ordinary condition, there is 13 per cent of carbonic acid, by volume, in the gases passing off.

Total Heat of Combustion.—The total heat of combustion of one pound of coal of average composition, having 80 per cent of carbon and 5 per cent of hydrogen, is

$$145\left[80 + (4.28 \times 5)\right] = 14.703 \text{ th. u.}$$

And as per formula previously given, the evaporating power will be 13.17 lbs. of water from 62°, and 15.22 lbs. from water at 212° per pound of coal.

COKE.

Coke is the solid residuum of coal from which the volatilizable portions have been removed by heat, a process which is illustrated in the action of ordinary furnaces, in which the gasified elements of coal are first burned off, and afterward the fixed or residuary coke. The quantity of coke obtained from an average coal is 76.4 per cent.

The quality of the coke obviously depends, in a great measure, on the proportions of the constitutent hydrogen and oxygen of the coal from which it is made, which regulate the degree of the fusibility of the coal when exposed to the heat.

Coke of good quality weighs from 40 to 50 pounds per cubic foot solid, and about 30 pounds per cubic foot heaped. The average volume of one ton is 75 cubic feet; the volumes vary from 70 to 80 cubic feet.

The average composition of coke is:

Carbon	93.44 per cent.
Sulphur	1.22 per cent.
Ash	5.34 per cent.
	100.00

COAL TABLE.

Mine.	State.	Per Cent of Efficiency.	Description.	Th. U.	Evap. 212°.	Fixed Carb.	Ash.
Superior........	Western.....	63.70	Nut..........	9848	10.19	44.02	15.80
Gillespie................	Western.....	64.57	Lump	11200	11.60	47.30	15.20
Wilderman.....	Western.....	66.63	Nut..........	10300	10.66	40.66	17.63
Belleville...............	Illinois	66.83	Mixed Lump and Slack.	10320	10.69	41.16	16.64
St. Clair	Illinois......	68.46	Nut	10578	10.95	41.96	15.40
Kansas and Iowa.......	Western.. ..	70.45	Mixed Slack.	10900	11.27	45.49	17.92
Southern Illinois......	Western.....	70.58	Lump	10905	11.29	43.78	13.87
Rentchler...............	Illinois	70.95	Run of Mine	10961	11.35	45.53	12.47
Collinsville.	Illinois	71.20	Lump	11000	11.39	40.35	13.28
Heintz Bluff............	Western.....	72.02	Lump	11126	11.52	43.68	13.35
Sugar Creek............	Illinois	72.52	Auburn Screenings.	11200	11.60	47.30	15.20
Mount Olive............	Illinois......	72.58	Nut	11217	11.61	47.29	8.29
Belleville...............	Illinois	72.64	Lump	11230	11.62	45.65	11.55
Mount Olive............	Western....	72.70	Run of Mine	11233	11.63	45.91	8.56
Mount Olive............	Illinois......	72.95	Lump	11278	11.67	42.37	10.08
Hurricane	Western.....	74.14	Lump	11455	11.86	53.07	10.80
Glen Carbon............	Western.....	74.26	Lump	11481	11.88	41.99	10.35
Cherokee................	Indian Ter..	75.46	Slack.	11675	12.07	48.09	14.78
Glen Carbon............	Western.....	75.58	Run of Mine	11674	12.09	44.75	9.27
Hocking Valley........	....	76.06	Run of Mine	11757	12.17	55.72	7.33
Murphysboro...........	Western.....	76.14	Lump	11766	12.18	.....	.....
L. V......................	L. V. Region	77.33	Pea	11920	12.37	76.28	16.23
Wilkesbarre............	Pennsyl'nia.	77.39	L. V. Buck-wheat	11959	12.38	78.29	15.50
Jackson Hill............	Ohio.........	78.14	Slack........	12100	12.50	59.20	10.20
Big Muddy......... ...	Western.....	78.90	Lump	12190	12.62	55.58	7.02
Cayuga, Scranton......	Pennsyl'nia.	79.83	....	12413	12.77	84.38	9.12
Gas House...........	Western.....	79.58	Coke.........	12300	12.73	82.74	14.60
Mount Pleasant, Scranton......................	Pennsyl'nia.	80.64	....	12458	12.90	81.59	10.78
Jermyn, Schuylkill....	Pennsyl'nia.	81.58	....	12316	13.05	82.90	11.02
Little Pittsburg, Morgantown...............	W. Virginia.	83.41	....	12800	13.30	55.90	6.60
Connelsville...... ...	....	83.15	Coke.........	12850	13.30	87.80	10.78
Forty Foot, Scranton..	Pennsyl'nia.	84.32	....	13045	13.49	84.92	10.01
Pocahontas.............	....	84.33	Lump	13049	13.49	75.02	5.60
Continental, Scranton.	Pennsyl'nia.	84.82	....	13170	13.57	84.19	10.03
Avondale.............	Pennsyl'nia.	85.70	....	13218	13.71	87.78	6.91
Bernmont, Monongahela....................	Virginia.....	86.90	....	13424	13.90	59.90	8.04
Antrim.......	Pennsyl'nia.	88.64	....	13695	14.18	70.16	11.30
Eureka, Clearfield Co..	Pennsyl'nia.	89.96	....	13897	14.39	70.39	5.82
Buck Mountain, Cross Creek................	Pennsyl'nia.	92.05	....	14220	14.72	92.41	4.12
Turtle Creek, Monongahela..............	Pennsyl'nia.	93.52	....	14450	14.96	60.72	4.33
Reynoldsville	Pennsyl'nia.	97.95	....	15134	15.67	69.96	5.37
Leisenring, Connelsville	Pennsyl'nia.	98.90	....	15285	15.82	64.49	6.25
Nova Scotia, No. 2 Slope, U. S...........	....	99.15	....	15324	15.86	63.61	4.11
Cooperstown	Nova Scotia.	100.00	....	15435	15.98	65.16	4.09

Coke is capable of absorbing from 15 to 20 per cent of its weight of water. It has been found to absorb as much as 8 per cent of water on its way from the ovens to its destination, in uncovered wagons. Directly exposed to rain, it may absorb 50 per cent of its weight of water. Most of the water is afterward quickly evaporated, leaving from 5 to 10 per cent in the coke.

LIGNITE.

Brown lignite is sometimes of wooden texture, sometimes earthy. Black lignite is either of woody texture, or it is homogeneous, with a resinous fracture. The coke produced from various lignites is either pulverulent like that of anthracite, or it retains the form of the original fibers. Lignite is less dense than coal.

The composition of lignite is:

Carbon	69 per cent.
Hydrogen	5 per cent.
Oxygen and nitrogen	10 per cent.
Ash	6 per cent.

Lignite yields about 47 per cent of coke.

WOOD.

Wood as a combustible can be divided in two classes:

1. The hard, compact, and comparatively heavy woods, as oak, beech, elm, ash.
2. The light colored, soft, and comparatively light woods, as pine, birch and poplar.

Green wood when cut down contains about 45 per cent of its weight in moisture. Wood which has been kept for years in a dry place retains from 15 to 20 per cent of water.

Ordinary fire wood is composed of:

Carbon	37.5 per cent.
Hydrogen	4.5 per cent.
Oxygen	30.75 per cent.
Nitrogen	0.75 per cent.
Ash	1.5 per cent.
Hydrometric water	25 per cent.
	100.00

A cord of pine wood measures 4x4x8 feet, and has a volume of 128 cubic feet. Its weight in ordinary condition averages 2,700 pounds, or 21 pounds per cubic foot.

If the wood contains 25 per cent of water, the weight of the direct products is 75 per cent of 8.45, which is the weight of the direct products of perfectly dry wood, i. e., it is 6.34 pounds, and the available heat is 7951 thermal units per pound.

In order to obtain the maximum heating power from wood it is the practice in some factories, as glass and porcelain works, where intensity of heat is required, to dry the wood fuel thoroughly before using it, even using stoves for the purpose.

Peat, Tan or *Straw* are not used for fuel commercially in this country, and therefore no data are given for same.

LIQUID FUELS.

Petroleum is a hydrocarbon liquid which is found in abundance in the United States and in Europe. All the different kinds show practically identical composition. Average specific gravity 0.870. Composition:

Carbon	84.7 per cent.
Hydrogen	13.1 per cent.
Oxygen	2.2 per cent.
	100.0

The total heating and evaporating powers of one pound of petroleum having the average composition, are:

$$\text{Total heating power} = 145\left[84.7 + (4.28 \times 13.1)\right] = 20{,}400 \text{ th. u.}$$

Evaporative power from 62° = 18.29 pounds.
from 212° = 21.13 pounds.

TEMPERATURE OF FIRE IN A BOILER FURNACE.

With a stationary boiler being under-fired with coal, having a large grate of 26 square feet area, the temperatures were found to be:

Over the center of the fire at different times..........	3200°	3610°	3405°
Over the bridge...	1730°	1730°	1735°

BOILERS.

1. *Horizontal cylindrical boilers,* outside firing, masoned in so as to expose two-thirds of the shell surface below to the combustion gases. Boiler should be suspended, and not supported, and be inclined somewhat toward the rear.

2. *Vertical cylindrical boilers,* which are used when space for *horizontal* boilers cannot be had. The boiler is surrounded

by a cylinder built of masonry, and the flue gases pass through the annular space between the two. The heating surface is not well utilized, as the vapor passes mostly along these surfaces and prevents a close contact of the water with same, and the iron is not protected from the action of the fire so well as in an horizontal boiler.

3. *Double horizontal boilers,* one erected above the other, and both connected by water legs of about 12 inches to 16 inches diameter, to facilitate the motion of the water, the upper one longer, and to receive the furnace.

4. *Three horizontal boilers,* one above and two below, connected by water legs, the upper one longer and provided with the furnace.

5. *Four horizontal boilers,* two above and two below, also connected by water legs. All these constructions aim at a good water circulation.

6. *Flue boilers,* masoned in so that the gases pass first under the lower part of the shell, and then through the tubes located numerously in the shell, and out in front through the smoke-stack. Or, the gases pass from under the shell to two flues located on either side of the shell, to the front, and return through the tubes to the back of the boiler to the smoke-stack. This is done to give the gases a longer way to travel and to utilize their heat better. The tubes are expanded in the two heads, and are in some cases located in two bundles, to facilitate cleaning of the boiler.

7. *Locomotive boilers.* A cylindrical boiler is provided with a square or round fire-box in front and a smoke-box in the rear. The tubes are expanded in the two heads, forming the inside of the fire-box and the smoke-box. This construction is necessary to avoid the brickwork. These boilers are mostly worked with forced draft, by injection of the exhaust forcing the air into the ash pit.

8. *Water tube boilers.* These consist of a battery of tubes connected together, each of which forms really a boiler by itself. The steam from all of them is collected in a steam drum. These boilers raise steam quickly and can be driven much over their capacity, but in that case deliver very moist steam. It *is best to use them* well within their capacity when desiring *dry steam.*

The connections of the single tubes are made in many different ways, each system being claimed to be the best by the respective builders.

a. "Belleville Boiler." The tubes are connected and placed so that the first vertical row inclines to the rear, the second to the front, and the third again to the rear, and so on.

Calling the tubes in first row 1, 2, 3, 4, and the second row 5, 6, 7, 8, reading from the bottom up, the tubes are connected 1 with 5, 2 with 6, 3 with 7, and 4 with 8, the connections being made in the rear. Then 2 with 5, 3 with 6, and 4 with 7, all connected in front.

b. "Schmidt Boiler." The tubes are connected like a vertical continual pipe coil. The inlets below and the outlets above are again connected by headers, so that the steam generated below must rise through all the upper tubes before it can reach the collecting drum.

c. "Root Boiler." The tubes are placed on an incline and so connected that the steam can escape from each tube directly and that each tube has its direct water supply.

9. *Vertical flue boilers.* The shell is cylindrical, and a cylindrical fire-box is built in the bottom, allowing a water space between shell and fire-box. The tubes are expanded in the top plate of the fire-box and into an extra head riveted into the boiler below its upper head, giving sufficient room for the flue gases between the two heads to reach the chimney, which is located in the center on top. Such boilers are mostly used where there is no room to place horizontal boilers.

It is evident that the space between the two shells will easily fill with scales, and afterward the inner shell, likewise, the fire-box will burn out, and although cleaning holes are provided to remove the scales from this place, it is not easy to do so. Moreover, since the level of the water rises and falls, leaving more or less of each tube exposed to the fire without protection from the water, the tubes will give out sooner, especially in the places where the water plays up and down continually. Another disadvantage is the forming of scale at the water level on the tubes. When the water recedes the scale is exposed to the direct action of the fire gases, and it will dry and crack. When the water rises again it enters the cracks and washes out the scale which has been charred by the action of the fire.

whereby the steam, and afterwards the condensed water, acquires that disagreeable smell and taste often found in artificial ice. To remove this taste is a very expensive operation, as it has to be done by charcoal filters, the charge of which must be frequently renewed and re-burned.

For ice-making purposes, therefore, such boilers should not be used.

Of all these boilers, only two kinds can be said to be really in general use, viz., the tubular, or flue boiler, and the water tube boiler. In the first, tubes of two inches, three inches, four inches, five inches, six inches are used, and smaller sizes in the water tube boilers.

For ordinary use, the tubular boiler is best. It is the cheapest, and requires the least space of the two. On the other hand the water tube boiler is a quick steamer, and where steam is required to be raised in the shortest possible time, it is preferable. If not overcrowded, it will also be more economical than the tubular boiler.

GRATES.

For natural draft and coal, give one square foot of grate surface for every 15 pounds of coal to be burned—length of grate 1.5 of its width. Grate to be inclined from one inch to 1.5 inches toward the rear per foot of length. If there is only a light draft, the grate surface should be increased, so as to provide one square foot for 12 pounds of coal burned.

The width of each bar should be made as small as possible consistently with the strength required, and the space between the single grates should be from 0.5 inch to 0.75 inch, according to the size of the pieces of the fuel used. Short grates give better combustion but slower evaporation.

Grates for Wood. The grate surface should be increased from 1.25 to 1.4 times of the surface required for coal. Ash pits should be so proportioned that the transverse section is 0.2 to 0.25 of the total grate surface for bituminous coal, and 0.25 to 0.3 of that for anthracite coal.

The *combustion chamber* for coal should have a volume of 2.75 to 3 cubic feet per square foot of grate surface, and for wood it should be 4.6 to 5 cubic feet per square foot of grate surface.

Bituminous coal requires also a somewhat larger combustion *chamber than* anthracite coal.

The velocity with which the air enters the ash pit should be twelve feet per second.

Grates have been constructed so that each individual bar, or sections of bars, can be turned, to remove clinkers, but their advantage is doubtful, as they easily get out of repair or are ruined if clinkers get between them.

Automatic raking grates are very good, and often used with success. They are constructed like two gridirons working within each other, propelled by eccentrics placed outside on a shaft, run by an engine. They will prevent the formation of clinkers, and settle the coal nicely. But it is a costly device and easily gets out of order.

Another arrangement is to construct the grate like a link belt, making it run over two rollers, one placed in front and one placed in the rear. These rollers revolve slowly and carry the coal forward, causing perfect combustion and no smoke. The clinkers and ashes form a bridge behind the furnace and are removed from time to time.

Another furnace is constructed so that the bars have a reciprocating motion, combined with a slight up and down motion, carrying the coal forward in the furnace, and, at the same time, breaking the clinkers by the up and down motion, which also facilitates the sliding of the coal, as the set of bars moving toward the front are a little below the true grate surface.

Automatic stokers are used to prevent the frequent opening of the fire door. There is some economy in them, where many boilers are placed in one room, as some help can be saved. The coal is fed into hoppers by hand, and the gears therein force it into the furnace; the air is forced into the ash pit by a blower, and the gears are moved by eccentrics fastened to a shaft outside the boiler.

In some cases a *coal conveyor* is employed to carry the coal from the coal elevator straight to the hoppers at the boilers, the elevator man attending to the conveyor, and, at the same time, to the unloading of the coal from the ship or car. In the hydraulic power plant in London, England, there is an arrangement of this character, very little help being employed for running three steam engines of 75 horse-power each, which furnish about 8,000 horse-power. This is never used all at once, and power is stored to a considerable amount in big storage tanks carrying 700 pounds' pressure to the square inch. Since

power is furnished to small merchants mostly, who use it for hoisting goods, which occurs at long intervals and for short periods at a time only, it is readily understood that it is possible with such small plant to furnish so much power. The amount of contracts entered into reaches about 8,000. The coal is taken from a boat in the Thames by a conveyor and delivered to the hoppers of the boilers. An automatic stoker and automatic moving grate bars are employed, and the machines start automatically as soon as the water in the tank is reduced to a certain point. All the help employed for the whole plant in one twelve-hour watch, besides the men in the boat, is one elevator man, one engineer and one boy for assisting the engineer and cleaning up.

RELATION OF GRATE SURFACE, HEATING SURFACE, FUEL AND WATER.

It is well known that, in a given boiler with a given furnace, the greater the quantity of fuel consumed per hour, the greater also the amount of water evaporated per hour. But the quantity of water evaporated increases at a less rate than the fuel consumed, that is to say, the quantity of water evaporated per pound of fuel is diminished. This diminution of efficiency is obviously due to the greater portion of wasted heat escaping by the chimney, as indicated by the higher temperature of the gases, which remains unused for evaporation.

The total quantity of water evaporated per square foot of grate surface is expressed by a constant quantity A plus a constant multiple $B\ c$ of the fuel c consumed per square foot of grate:

$$w = A + Bc.$$

By experiments it has been found that the amount of the fuel increases with the square of the grate surface, and we can make $A = ar^2$, wherein both a and B are constant for each kind of boiler. $r = \frac{h}{g} = \frac{\text{heating surface}}{\text{grate surface}}$; c = pounds of fuel consumed per square foot of grate surface; w = amount of water evaporated.

Water evaporated at 212°:

Stationary boilers......... $w = 0.0222\, r^2 + 9.56\, c.$

Marine boilers............ $w = 0.016\ r^2 + 10.25\, c.$

Portable engine boilers..... $w = 0.008\ r^2 + 8.6\ c.$

Locomotive boilers (burning coal) .... $w = 0.009\ r^2 + 9.7\ c$.
Locomotive boilers (burning coke) .... $w = 0.0178\ r^2 + 7.94\ c$.

The limiting values of c are:

Stationary boilers.................. $c = 0.00755\ r^2$.
Marine boilers..................... $c = 0.007\ r^2$.
Portable engine boilers............ $c = 0.002\ r^2$.
Locomotive boilers (coal).......... $c = 0.00325\ r^2$.
Locomotive boilers (coke).......... $c = 0.0044\ r^2$.

On an average, the allowance should be twelve square feet of heating surface—figuring only tube surface—per horse-power per hour, for tubular boilers, and 10 to 12 square feet per horse-power per hour for water tube boilers.

SETTING OF BOILERS.

Where mason work comes in direct connection with the boiler, no mortar should be used, but only fire clay. All connections close to the boiler and below the water line should be made with firebrick. The firebricks should be moistened when laid, and have very thin joints, and every third course should be bound to the rest of the brickwork. The thickness of the walls should not be less than one and one-half brick, better two bricks, and the outer wall should have an air space of two inches. Both walls should be bound together by a binding course at every third layer.

If parts of a boiler pass through brickwork, as, for instance, the dome, the brickwork should be kept away from it at least one or two inches.

The flues must be so built that a long and close connection of the flue gases with the boiler is had, and must be easily accessible for cleaning. It is best to place obstructions in the flues or to curve them to bring the gases in close connection with the boiler. These obstructions should be placed at distances of five to eight feet apart.

The velocity of gases with natural draft should be about ten to fifteen feet. It is not necessary to have the cross-section equal all through.

As a general rule, if three consecutive flues are used in a boiler using from 150 to 250 pounds of coal per hour, the last flue should have an area equal to 0.25 of the grate surface, ar

the first one 1.5 to 1.75 of this, and the last but one 1.25 to 1.5 of the last one.

In places where obstructions are put on purpose, as those in the flues and the bridge, they can be made with an area of 0.125 to 0.1 of the grate surface. Where the direction of the flue gases is changed, larger areas must be provided, as this change of direction will otherwise retard the flow of the gases.

SMOKE-STACKS.

The smallest opening of the chimney should be one-fourth of the grate surface, and its height about 25 times this smallest opening, but never under 50 feet.

Chimneys which are built without means for ascending on the outside must have an opening at the top of not less than 24 inches. The lower diameter of a brick chimney should be 0.02 of the height of the chimney larger than that of the top opening.

Round chimneys are best because they offer less resistance to the wind, do not retard the revolving action of the gases, and having the smallest circumference for a given diameter, suffer the least from loss of heat. The bottom of the opening of the chimney should be at least 24 inches to 30 inches from the bottom of the bridging and if more than one bridging enters the chimney they should be so arranged as to give the gases from all of them the same direction, as otherwise a considerable loss of velocity would occur.

Brick chimneys are best, but also the most expensive. They last long and need no painting, nor much repairs, except pointing up once in a long while. They retain the heat much better than iron smoke-stacks.

Iron smoke-stacks are either made self-sustaining or are held by guy ropes. In the first case, the stack is provided with a strong cast-iron base, bolted down upon a foundation heavy enough to prevent the strongest wind overturning the stack. The stack is also made of heavier iron. The necessity of keeping in paint, and the danger of rusting on the inside if not continually in use, are two disagreeable conditions connected with the use of iron chimneys.

SMOKE PREVENTION.

If smoke issues from a chimney it is a sure sign that *combustion is imperfect.* The means to prevent smoke is to heat

it and to admit air either at ordinary temperature or heated. This can be done in quite a number of ways:

1. *The air enters into the bridge* from the sides, rises in it to the top, and is discharged at the top downward into the fire.

2. *Air admitted through a flue,* located behind the ash pit and controlled by a butterfly valve. This air mixes with the smoke right behind the bridge and consumes it. It is claimed that this process will save 37 per cent of the fuel when using soft coal. But the objection is that if the fireman admits too much air, the efficiency will not be increased but decreased.

3. *Mr. W. Losh* provides two separate furnaces and fires them alternately, allowing the gases of the just fired furnace to pass into the ash pit of the other, which has yet an incandescent fire, thus consuming the smoke.

4. *Air tubes perforated* with holes are placed behind and near the bridge, discharging air taken from the outside into the smoky gases, and furnishing the oxygen needed to transform them into carbonic acid gas.

5. *Mr. Williams* admits air through a flue located behind the ash pit, discharging it into the ash pit through perforated fire-clay plates, and admits additional air through a perforated fire door. He makes the air inlet at the fire door 0.5 to 1.5 square inches per square foot of grate surface.

6. *Mr. March* builds two furnaces, the grates of which can be moved up and down, carrying a deep bed of fuel at the start, and keeping the fuel always at the same level. The furnaces are filled alternately. The air is sent by a blower into tubes located in the bottom of the boiler and connected by outlets with the combustion chamber, the air striking the fire vertically.

7. *Mr. Clark* places six three-inch air tubes just over the fire door, and introduces the air by six steam jets of $\frac{2}{32}$ of an inch each, directing air and steam toward the opening between bridge and boiler.

8. *Another method of Mr. Clark* is to place cast-iron plates over the fire door, forming a narrow air inlet, and to place in them steam jets to introduce the air, directing the current again as before. He had the best action with this arrangement over a deep fire.

9. *Dr. Kufahl* built a step grate like a flight of stairs for the *use of small coal, lignite, and slack.* This arrangement is simpl

a lot of grates placed so that the fuel from the first grate cannot fall in the ash pit, but falls on the next grate, getting hotter all the time and nearer the point of incandescence. All these steps are a little inclined, except the lowest one, which is a little larger and level for the removal of the clinkers.

10. *Hawley Down Draft Furnace.* This furnace is provided with two grates, located one above the other; the lower one is an ordinary grate, and is not fired, but receives its supply from the grate above, which allows the coked coal to fall through. The upper grate is formed by a series of pipes, connected rear and front, and the front header receives the water from the boiler, while the rear header returns it, causing a rapid circulation of the water in the boiler. The coal is fed to the upper grate, and the gases produced in the upper furnace forced to pass through the coal on the upper grate, since a wall erected right where otherwise the bridge would be, stops the progress of the gases and leads them through the coal downward, where they meet the coked fuel, and thus the smoke coming from the upper furnace is burned. The gases then flow as usual into the flues, toward the chimney. The upper grates are inclined toward the front, about three inches per foot of length, and the lower grates inclined toward the rear about two inches per foot.

It is claimed that this apparatus prevents smoke entirely and increases the economy materially. It certainly has two good features, viz., perfect combustion and rapid circulation of water. The makers claim the following for their furnace: It will consume 30 to 40 pounds of coal per hour per square foot of grate surface, and not smoke; evaporate 15 to 35 per cent more water than any other furnace per pound of coal; increase capacity of boiler 20 to 40 per cent; insure safety of boiler by preventing bagging or burning of shell. The claims are certainly high, and should be substantiated by a guarantee from the maker.

FEED-WATER HEATERS.

The *simplest heater* is one in which a pipe coil of equal diameter as the exhaust pipe is submerged in a tank filled with water, the steam entering the coil at the top and the condensed water *discharging at the* bottom through the shell, the steam through *a tee placed inside* the tank to the top. If the coil has suffi-

cient heating surface, it is a useful device, but it will require an enormous heating surface, owing to the slow motion of the water over it, and it cannot be expected to bring the feed water near 212°.

The *heaters ordinarily used* are either horizontal or vertical cylindrical vessels, filled with brass tubes, and are constructed like steam condensers. In case an old tubular boiler is on hand, it can be used to advantage as a feed-water heater. The water is fed in the shell, and the exhaust into the tubes.

There are some vertical heaters built with only one tube plate, the pipes having return bends, and the inlet and outlet of each pipe being secured to the same tube head. This is done to prevent leakage at the tube heads caused by expansion and contraction, the bent pipes taking care of the expansion.

The *Bauer heater* is an exhaust heater, oil extractor, and purifier, at the same time. It consists of two cylinders, a larger one below and a smaller on top, forming the oil separator. The exhaust steam enters the upper vessel on top and strikes a lot of obstructions, placed there for the retention of the oil carried along with the steam. At the bottom of this upper cylinder the feed-water is introduced and flows over the edge of a tube inserted as a connection between the upper and lower vessels in a thin sheet, meeting the steam on this passage and taking up heat from it. The water then drops on corrugated baffle plates, so arranged that the water runs over on the outside of one baffle plate and over at the center of the next baffle plate. Having been heated to the boiling point by this time, it liberates lime and other substances held in solution, and leaves them on the plates. The water and exhaust steam now pass through filtering material and collect in a spacious receiving compartment at the bottom of the large cylinder, where they are separated. The feed-water supply is regulated by a float, located in the receiving compartment, keeping the water-level there at even height by means of rods and levers acting on a balanced valve located in the feed-water inlet pipe.

The steam coming in direct contact with the water, there will, of course, be a closer exchange of heat than if both were separated by sheets of iron, and the water will be purified just as in a live-steam heater, to the extent, of course, that this can be done *without* raising the temperature of the water as *high as in the live-steam* heater. Some substances still remain in

solution at 212°, while they will precipitate at a temperature of 340°.

The *Holmes condenser* (See Condensers) can be used as a heater, where it is advisable to condense the steam, either for the purpose of using the distilled water or because the escape of the exhaust must be prevented, and where plenty of water is on hand.

LIVE-STEAM HEATERS.

If it is necessary to heat the water almost to the temperature of live steam in order to get rid of substances carried in solution in the water at temperatures lower than that of the live steam but higher than 212°, the only heater to use is a live-steam heater.

When a compound condensing engine is on hand and the exhaust is not available for feed water heating, it pays to use a live-steam heater. Not that there is any gain in economy, since it is immaterial where the work of heating the feed-water is done, coal having to be used anyway, either to produce the live steam to heat the water with, or to heat the water directly in the boiler.

The live-steam heater is generally a horizontal, cylindrical vessel, wherein the live steam comes into direct contact with the water. A large number of pans are provided inside, over which the water is run from one to the other. The pans retaining the substances dropped out of solution at this high temperature, must be cleaned from time to time. This heater will furnish good feed-water and at evaporating temperature; it will increase the capacity—not the efficiency—of the boiler, and prolong the life of the boiler by subjecting it to less strain, keeping the temperatures prevailing in the different parts of the boiler more equal.

To show how much saving can be obtained by the use of a feed-water heater, we will assume that we have one 100 horse-power boiler, evaporating 30 pounds of water per hour, that the coal furnishes 6,000 th. u. per pound, and that the feed-water is 72° before entering the heater and 210° when leaving it. We then have $24 \times 100 \times 30$ pounds of steam to produce per day and, therefore, need just this amount of feed-water, which we can heat by the exhaust, without any expense whatsoever, from 72° to 210° = 138°. We have therefore furnished $24 \times 100 \times 30 \times 138$ th. u. to the water which we need not

furnish in the boiler, by using a feed-water heater; or, if we divide this sum by 6,000, we have the amount of coal saved per day = 1,656 pounds of coal = 0.828 tons.

ECONOMIZERS.

The flue gases often carry large amounts of heat out through the smoke-stack, allowing it to go to waste, especially when boilers are forced, or high steam pressure is used. To save this heat, water pipes can be laid in the bridging, and the extra heat used to heat the water circulated through these pipes, often to a higher temperature than an exhaust heater can do. It might even pay to use the exhaust first for heating the feed-water, and then to send the feed-water through the economizer.

The table below shows the results obtained from a carefully conducted test made by Mr. M. W. Grosse at the works of Messrs. Dollfus, Mieg & Co. of Mulhouse in Alsace (page 218).

GREEN ECONOMIZER.

The apparatus with which the Grosse test was made consists of four ranges of vertical pipes 6½ feet high, 3¾ inches in diameter outside, 9 pipes in each range, connected at top and bottom by horizontal pipes. The water enters all the tubes from below and leaves them above. This system of piping is enveloped in a brick casing, into which the gaseous products of combustion are introduced from above, leaving it from below. The pipes are cleared of soot externally by automatic scrapers. The capacity for water is 24 cubic feet, and the total external heating surface is 290 square feet. The apparatus is placed in connection with a boiler having 355 square feet of heating surface.

This apparatus had been at work for seven weeks continuously without being cleaned, and had accumulated a one-half-inch coating of soot and ash, when its performance in the same condition was observed for one week. During the second week it was cleaned twice every day; but during the third week, after having been cleaned on Monday morning, it was worked continuously without any further cleaning. The coal used was a smoke-making one, and the consumption of it was practically made constant.

Time.	Temperature of Feed Water.			Temperature of Gaseous Products.		
February and March.	Entering Feed-Water Heater.	Leaving Feed-Water Heater.	Difference.	Entering Feed-Water Heater.	Leaving Feed-Water Heater.	Difference.
First week.......	73.5°	161.5°	88 °	849°	261°	588°
Second week.....	77. °	230 °	153 °	882°	297°	585°
Third week.						
Monday	73.4°	196 °	122.6°	831°	284°	547°
Tuesday........	73.4°	181.4°	108.0°	871°	309°	562°
Wednesday.....	79.0°	178.0°	99.0°	.. °	...°	...°
Thursday	80.6°	170.6°	90.0°	952°	329°	623°
Friday	80.6°	169.0°	88.4°	889°	338°	551°
Saturday	79.0°	172.4°	93.4°	901°	351°	550°

The averages for first and second week are taken exclusive of Mondays.

	1st Week.	2d Week.	3d Week.
Coal consumed per hour....................	214 lbs.	216 lbs.	213 lbs.
Water evaporated per hour from 32°.......	1424 lbs.	1525 lbs.	1428 lbs.
Water per lb. of coal......................	6 65 lbs.	7.06 lbs	6 70 lbs.

The table shows that there is a great advantage in cleaning the pipes daily, the elevation of temperature having been increased by it from 88° to 153°. In the third week, without cleaning, the elevation of temperature relapsed in three days to the level of the first week; even on the first day it was quickly reduced by as much as half of the extent of the relapse. By cleaning the pipes daily, an increased elevation of temperature was obtained, while a gain of 6 per cent was effected in the evaporative efficiency.

BOILER WATER AND ITS TREATMENT.

There is no part in the operation of a steam plant which is of greater importance and which should receive more careful attention than the proper use of scale-preventing compounds. The forming of scale and other common boiler evils will here be treated from a theoretical as well as a practical standpoint, giving the causes, effects and methods of treatment.

WATER IN GENERAL.

Chemically pure water does not exist in nature, the nearest *approach to it being rain* water or melted snow; but even this is *never pure, for in falling* it dissolves or washes down with it

the gases, dust, germs, etc., which are always present to a greater or less extent in the air. Rain, after reaching the earth, soaks down into it and in percolating through the various strata dissolves certain salts or minerals, the quantity and kind of which varies with the nature of the strata, with which the water comes in contact. It reappears in the form of springs or artesian wells and in that stage contains considerable mineral matter in solution, being usually what is termed a hard water.

These springs are generally the source of rivers and feeders of lakes whose water, coming in contact with the air, loses part of its dissolved minerals, and being increased in volume by the rain falling directly, and that running off the surrounding land, becomes very much diluted and moderately soft. It may also contain organic matter from decomposing vegetable substances and sewage and other impurities from cities and factories situated along the river course. (For more detailed treatment of waters in regard to this requirement in brewing see Chapter on "Brewing Materials").

WATER FOR BOILERS.

The greater part of the substances in solution to be considered in water for boiler purposes are sulphates and carbonates of lime and magnesia, and carbonate, chloride and sulphate of soda; although chloride of magnesia, carbonate of iron, alumina, silica, potassium salts, and organic matter and gases are often present, but only in small quantities.

HARD AND SOFT WATERS.

Boiler waters may be considered from two points of view and described accordingly as hard, or scale-forming, and soft waters.

Hard waters are those that contain considerable amounts of earthy salts in solution, such as carbonate and sulphate of lime and carbonate of magnesia. Hardness of water is designated as either temporary, or permanent.

By temporary hardness is meant hardness caused by such earthy salts as will disappear from solution, or, in other words be precipitated by boiling or aëration. These are the carbonates of lime, magnesia, and iron, which are almost insoluble in pure water, but quite soluble in the presence of carbonic acid gas (*contained in nearly* all waters) with which they form bicarbonates

These, however, are unstable for, on boiling or aërating the water, this carbonic acid is readily driven off, and the soluble bicarbonates are precipitated as insoluble carbonates.

Permanent hardness of a water is caused by the earthy salts remaining permanently in solution, and will not be precipitated by boiling at 212° F. or by aëration. These are sulphate of lime or gypsum, sulphate of magnesia, and very small quantities of the carbonates of lime and magnesia.

Soft Waters are those that contain very little or no solids in solution.

The best water for use in a boiler is undoubtedly rain water or condensed steam containing practically no solids in solution, next, river or lake water with an average of from 5 to 10 grains of solids per gallon, and lastly, spring or artesian well water which is generally quite hard.

TREATING HARD WATERS.

When a hard water must be used, it is best treated for the removal of its solids before entering the boiler, as even moderately soft water becomes troublesome in the boiler on account of the aggregation of the solids due to drawing off the steam and adding new water. For example, taking a soft water with only five grains per gallon and calculating as an average 3½ gallons of water evaporated per hour per horse power, then an engine of 100-horsepower running ten hours per day would consume 3,500 gallons. From this would then be deposited over two pounds of scale per day or nearly 70 pounds per month, or over one-third of a ton in the course of a year. With hard water these figures would be multiplied many times.

Water for boilers should not be judged by its appearance. A good drinking water may be a poor boiler water, a clear, sparkling water may be very hard and form dense scale, while a dirty river water often is soft and excellent for boiler use.

EFFECT OF WATERS ON BOILERS.

The evils in a boiler caused by different waters are of three kinds: Incrustation or boiler scale, corrosion of the metallic parts, and foaming, frothing, or priming.

SCALE.

Scale is by far the most common, the prevention and removal of which after once formed, is the purpose of nearly all the boiler compounds now in use. It is a hard, almost metallic coating or crust of lime and magnesia salts that forms on the walls and around the flues in the boiler. It operates most detrimentally by its non-conductivity of heat, as it acts as an insulator between the heated metal and the water to be heated, similar to a sheet of asbestos placed in the same position. This causes part of the heat to pass through the flues and up the chimney unused, involving a waste of fuel. This loss of heat and fuel varies with the composition of the scale, some kinds being more heat-resisting than others. The high limits are placed at 15 per cent loss of fuel for every 1-16 inch thickness of scale, but the average is somewhat lower on account of the varying composition of the scale from different waters, a fair average for every 1-16 inch thickness if scale is about 8 per cent, making the loss of fuel for a thickness of ⅝ inch about 80 to 85 per cent.

Where the scale is of considerable thickness it is of such resisting power as to allow the iron to become red-hot while keeping up the amount of heat necessary to maintain the required pressures. In this red-hot condition the plates and tubes are likely, owing to the high pressures to which they are subjected, to be bent out of shape or collapse entirely. There is further danger of the scale suddenly cracking or breaking away bodily from the iron, thereby allowing the water to come in contact with red-hot metal, often causing an explosion. Scale increases any unequal expansion of the whole structure which has a weakening effect, causing leaky seams and cracks in the plates near the rivet holes.

Soft scale or mud stops up feed pipes, water and steam gauge tubes, promotes the leaking of cocks and valves and may be carried over with the steam into the engine.

SCALE-FORMING SUBSTANCES.

The principal scale-forming solids in water are sulphate of lime and magnesia, and the carbonates of lime, magnesia and iron.

Sulphate of Lime or Gypsum is by far the worst enemy of a boiler, as it forms a dense non-conducting scale of almost metallic hardness. Its removal is the first and principal consideration i

the treatment of a boiler water. When contained alone it is not generally precipitated by boiling at 212° F., but partly in the presence of much bicarbonate of lime or magnesia.

Carbonate of Lime is almost insoluble in water (about two grains per gallon at 60° F.) and entirely so at 297° F., the temperature at 50 pounds' pressure. When held in solution as bicarbonate it begins to be slowly precipitated at 175° F., the bulk falling between that temperature and 212° F. It does not settle easily during working hours on account of the continual circulation of the water in the boiler, and the scale it forms is comparatively soft, except when allowed to lie on very hot surfaces not exposed to the circulation or when mixed with sulphate of lime, clay or grease.

Carbonate of magnesia acts almost exactly the same as carbonate of lime. It is worthy of notice that while a gallon of water will hold dissolved (in the absence of carbonic acid) either two grains of carbonate of lime or two grains of carbonate of magnesia, it will not under ordinary conditions dissolve two grains of each.

Sulphate of magnesia is usually contained only in small quantities in waters. It is not liable by itself to cause any scale, is not corrosive, and does not cause foaming, but it hinders the removal of lime salts and forms a moderately hard scale in the presence of carbonate of soda.

Oxide of magnesia is frequently, or even generally, present in the scale, although none is contained in the water. This is due to the carbonic acid of the carbonate of magnesia being driven off at high temperatures such as the plates and tubes are subjected to.

Carbonate of iron acts like carbonate of lime or magnesia, except that it begins to be precipitated at a lower temperature, as when standing in an open vessel in contact with the air, losing its carbonic acid and taking up oxygen.

Silica and alumina are contained in almost every water, usually combined with each other. They are of little importance, the total amount being seldom more than one-quarter of a grain per gallon.

Clay is frequently present in suspension; it has a tendency to mix with and increase the bulk of the hard scale.

Oil and grease that might find their way into the boiler are

to be avoided, as they mix with the otherwise porous, hard scale, and make it impervious to moisture, thereby increasing its non-conductivity or insulating properties. If of animal origin (adulterations in lubricating oil) they form oleates of lime and magnesia (insoluble soap), a sticky, non-conducting substance, having a great affinity for hot metal.

CORROSION.

Besides scale-forming solids there are contained in water other solids and gases that have a corrosive action on the metal of the boiler. This corrosion is very often a greater annoyance than scale, as it causes the metal to be eaten away, bringing on leaks, which generally result in loss of time by stoppages, and expensive repairs. The corroding solids are generally present in moderate quantities only, but become troublesome by their concentration, as they do not find an outlet until the whole boiler is emptied. They are readily decomposed by the high pressure and heat, liberating free acids which will either attack the iron directly or set up a galvanic action when brass or copper (cocks, valves, etc.) come in contact with the iron. In this event the iron (which means the boiler itself) is the metal attacked or corroded, being gradually eaten away. The substances usually causing corrosion are:

Magnesium chloride, which is split up at a high heat and pressure, liberating hydrochloric acid which not only corrodes the boiler but, being a gas, may pass over with the steam into the engine. Ammonium or sodium chloride (common salt) when present will, to a great extent, prevent this decomposition, forming with the magnesium chloride a stable double chloride.

Gases, such as carbonic acid, air, oxygen, and sulphuretted hydrogen are corrosive when in a moist state. It is a fact that distilled water out of which all the air has been boiled will not corrode or rust iron readily, neither will dry air or carbonic acid gas, but when together, as they are in boiler water, they will soon attack the metal. These gases will either form bubbles, and cause what is called pitting, or, if present in larger quantities (which is sometimes the case with air that is forced in by defective feed pumps) and being heavier than steam, will form a *stratum between the* water and the steam, causing corrosion at *the water line.*

Acid Waters.—Some waters are of an acid nature containing dissolved organic acids from having percolated through beds of peat or decaying vegetable matter. Water from rivers in lumber regions where large rafts of trees and bark are floated often contain tannic acid, and waters of the iron regions sometimes contain sulphuric acid.

FOAMING.

Foaming, priming or frothing in boilers has no deleterious effect on the boiler itself, but causes either non-volatile particles or the water itself to be directly carried over with the steam into the valves, pipes and engine. Muddy deposits of soft scale are causes of foaming, as the steam on this account rises through the water more irregularly and in large bursts or bumps carrying up with it a spray of this mud, and forcing it into the pipes. This is to be especially avoided in breweries using live steam in the mash tubs, since non-volatile matter as well as volatile matter thus carried may cause serious disturbances in mashing, etc.

Foaming is also caused by *carbonate of soda* or other *alkalis* that are sometimes contained in water, but are more often present in consequence of the addition of excessive amounts of water purifiers or boiler compounds, of which they are constituent parts.

BOILER SCALE PREVENTATIVES.

By a boiler compound or water purifier is understood such a substance as, when added to a boiler water, will lessen or entirely overcome the ill effects described in the foregoing paragraphs.

Proprietary Compounds.—There are innumerable compounds of secret composition in the market. Part of them give good results with some waters when properly used, others are indifferent or inert to any water, while the greater majority of compounds are positively injurious when promiscuously used. Some compounds, while they reduce scale-forming, increase corrosion, others become dangerous when used to excess, causing more scale than would be precipitated if no compound were used at all, but all compounds by their addition increase the density of the water and consequently its boiling point.

To Be Specially Compounded.—A boiler compound or water purifier should always be specially compounded to suit the water to be treated. A certain substance in the compound may be of benefit by eliminating a certain constituent in the water, but form injurious compounds with others. Therein lies the danger of using the many secret or proprietary compounds now in the market. The manner of using them is always the same; they are "guaranteed" to remove scale already formed, no matter how thick or of what nature, and to purify any water irrespective of what it may contain in solution.

It should be further considered that waters from different localities are seldom, if ever, similar in composition; even water from the same well or river changes its composition at different seasons of the year or after heavy rains. Furthermore, a compound should be used in the exact amount necessary, as too little does not accomplish the desired result and an excess is a waste of money, besides being liable to impair the quality of the water.

APPLICATION.

There are three methods of applying substances for the treatment of boiler waters:

1. In settling tanks where the water can be treated while cold. This applies to waters rich in carbonate of iron, suspended clay, organic matter, sulphate of lime, carbonates of lime and magnesia, and acid waters that are to be neutralized before use. This method is by far the most preferable and economical as it removes the objectionable substances before entering the boiler.

2. In the feed-water heater when the water contains substances best removed by the application of heat.

3. In the boiler itself. This is allowable only with waters of medium hardness or where a settling tank or feed-water heater is not installed. Also where there are several boilers which can be used alternately so that one can be properly cleaned while the others are being used. These last methods are, however, not advisable as the boiler is the most costly apparatus of the three, and by softening the water before reaching the boiler not only a saving in annoyance and labor is effected, but also a great reduction in the daily expense for fuel.

SUBSTANCES IN GENERAL USE.

The substances of known composition in general use as boiler compounds and water purifiers are the following:

Carbonate of Soda or "Soda."—The action of carbonate of soda is entirely of a chemical nature and its chief effectiveness depends on its ability to decompose sulphate of lime or gypsum (hard scale producers), change it into carbonate of lime (soft scale), and cause its precipitation in that form. It also affects the precipitation of the carbonates of lime and magnesia in the boiler, causing these carbonates to be deposited in a more flaky condition, with less tendency to pack or harden. Carbonate of soda decomposes the corrosive chloride of magnesium, forming carbonate of magnesia which is precipitated, and sodium chloride. It neutralizes any free acids that may be contained in the water which would otherwise corrode or pit the iron.

Carbonate of soda has no effect in preventing or diminishing the amount of scale, but in some instances increases it, as it precipitates carbonate of magnesia from sulphate of magnesia, which would otherwise remain in solution and do little harm to the boiler. It forms a soap with grease, which is more harmful than the grease itself. When added in excess, it causes foaming, especially in tubular boilers, and when used in considerable excess it attacks the packing and gaskets, having a tendency to dissolve asbestos and rubber. Carbonate of soda should be used only in waters rich in sulphate of lime, but not in those containing principally the carbonates of lime and magnesia. To apply carbonate of soda it should be dissolved in water separately and added to the water to be treated in such quantity as to produce a faint red color on the addition of a solution of phenol-phthalein. (See "Chemical Laboratory.")

Caustic Soda Process.—This does not immediately precipitate sulphate of lime, but does so in a secondary manner. It should be used, if at all, in waters containing mostly bicarbonates of lime and magnesia, besides sulphate of lime in a quantity approximately equivalent to the carbonates. Here it combines with the carbonic acid of the bicarbonates precipitating them as carbonates, and is itself changed into carbonate of soda, which further acts on the sulphate of lime as mentioned above. Caustic soda should be used cold in the settling tanks,

as a strong solution suddenly put in the boiler will not act to its full capacity or perform its work properly.

Lime.—The lime, or Clark's, process is applied to, and effective in, waters containing much, or mostly, bicarbonate of lime and magnesia, and little or no sulphate of lime. Here the lime, in solution as lime water, unites with the carbonic acid of the bicarbonates and precipitates them, as well as itself, as insoluble carbonates. This precipitate with lime is double the quantity what it would be if caustic soda were used; but, in the absence of sulphate of lime, has the advantage of not leaving any carbonate of soda in solution. The drawbacks of the latter were alluded to above. Lime is detrimental in the presence of sulphate of magnesia, as it precipitates hydrated oxide of magnesia and leaves sulphate of lime, which is more harmful, in its place.

Lime and Soda Combined.—This is used when water contains both sulphate of lime and bicarbonate of lime and magnesia in such proportion that the amount of carbonate of soda necessary does not have its full softening effect. The treatment in this process is accomplished by the addition of the amount of soda necessary to precipitate the sulphate of lime, and the amount of lime necessary to react on the carbonates. The combined method gives results where either alone would do so only imperfectly. Water should be treated by this process only while cold and in tanks.

Besides the above, there are other substances acted upon; but these are generally present in too small quantities to be considered. They are carbonate of iron, which is affected similarly to the carbonates of lime and magnesia and chloride of calcium, which acts like chloride of magnesium.

Barium salts are used to some extent. Caustic baryta acts like lime, and has no advantage over it. Chloride of barium precipitates insoluble sulphate of barium from sulphate of lime, leaving chloride of calcium in solution. This might answer where the water contains exclusively sulphate of lime, but it also forms a precipitate with sulphate of soda and sulphate of magnesia, unnecessarily increasing the precipitate and leaving the harmful chloride of magnesia in solution. The price of barium salts is, however, too high in comparison with other substances of equal or greater effectiveness to make their use general.

Sodium fluoride is practically the same in its action as car-bonate of soda, but is much more costly. It precipitates lime and magnesia salts in a light, flocculent, non-adhesive consistency, and when pure has the advantage over soda of not leaving the water so strongly alkaline. As a good many commercial samples react strongly acid there should be some care exercised in its use.

Tri-sodium phosphate, or *T. S. P.*, as it is sometimes designated by engineers.—The value of this chemical consists in its ability to convert the soluble lime and magnesia salts in the water into, and precipitating them as, insoluble phosphates of lime and magnesia. These phosphates are of a very flocculent nature, having a specific gravity little above that of water, and on that account do not settle easily, but are continuously in suspension, and settle when the boiler is at rest as a soft mud that does not harden. Tri-sodium phosphate, on account of its alkaline nature, neutralizes any acids present which would otherwise cause corrosion, and an excess is not so likely to cause foaming or priming, as would one of carbonate of soda.

Bi-chromate of Soda.—The use of this chemical is patented in Germany, and has recently been introduced here. It precipitates scale-forming lime and magnesia salts as insoluble, non-scaling chromates. It is claimed that an excess of the chemical, even free chromic acid, has no corrosive action on the iron or packing.

Tannin or tannic acid is used to some extent. It forms non-scaling tannates of lime and magnesia, but attacks the iron, and is not to be recommended.

Tannate of soda, like tannic acid, forms tannates of lime and magnesia, but is much safer to use.

Sugar is also sometimes used, precipitating the saccharates of lime and magnesia.

MECHANICAL COMPOUNDS.

A good many chemically inert substances are used as water purifiers, but they accomplish their object only partly, if at all. Such are:

Sawdust.—This is supposed to furnish a nucleus or center *for the crystallization of* the hardening salts preventing their *uniting together.*

Mucilaginous substances, starch, potatoes, etc., have the opposite effect to that of sawdust, that is, to envelop or surround the minute crystals of scale, and thus prevent them from hardening. Such substances, however, cause foaming and priming.

TO PREVENT CORROSION.

For the prevention of corrosion an iron-zinc couple is frequently used and seems to give good results. This is obtained by attaching zinc plates or rods to the iron bracings of the boiler, whereby a galvanic action is set up. The corroding substance attacks the zinc, which can be easily and cheaply replaced, leaving the iron of the boiler practically intact.

GENERAL RULES.

In the proper selection of boiler compounds or water purifiers the following considerations should be observed: Never use any of the so-called universal compounds, alleged to be good for any scale or any water. There are numberless small concerns or individuals going into this sort of "business" every year who claim to have the best compound ever produced and who recklessly condemn that of every other competitor. All they ask for is a trial of their compound, which means neither more nor less than experimenting with your boiler at your expense and risk. The greater part, in fact nearly all, of the secret compounds now sold are nothing but a mixture in varying proportions of some of the chemicals described above, usually sold at from three to twenty-five times their actual cost, the basis of most of them being soda, colored or blended in every imaginable manner.

Deal only with reliable concerns of financial standing, such as will actually make an analysis of your water, and furnish you a duplicate of the analysis, and who will prepare a compound to suit your particular water.

TRANSMISSION OF POWER.

In order to explain what is necessary to determine when shafting has to be erected for the transmission of power, we will take the most common case.

An engine of twenty-five horse-power is to be connected to a shafting supplying, by means of three pulleys *B*, *C* and *D*, power to different machines (Fig. 54). The machine connected to *B* requires five horse-power, the machine connected to *C* requires eight horse-power, and the machine connected to *D* requires twelve horse-power. Diameter of pulley $B = 6''$; diameter of pulley $C = 18''$; diameter of pulley $D = 20''$; revolutions of engine $= 75$; revolutions of shaft $= 100$. The diameter of the pulley A' on the engine is $= D$ and $= 32''$. The diameter of pulley *A*, width of all belts, and the diameter of shaft are to be determined; also the bearings to be placed at the proper places.

DIAMETER OF PULLEY ON ENGINE.

Calling the respective number of horse-power to be transmitted $= h, h', h'', \ldots$ and the radii of the corresponding pulleys $= r, r', r'', \ldots$ we have

$$25 \text{ HP.} = 5 + 8 + 12 = h + h' + h''.$$

The diameter *D* of pulley *A*, which is to be driven by pulley A', calling the revolutions of the engine $= N$, and of the shaft $= n$, we have

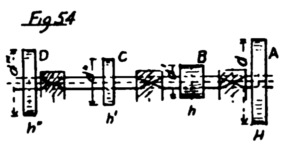
$$D : d = n : N; \; d = \frac{D N}{n} = \frac{32 \times 75}{100} = 24''; \; r = 12''.$$

WIDTH OF BELT FROM ENGINE.

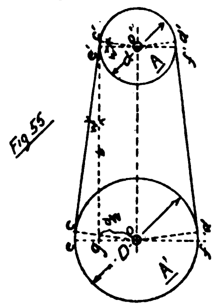
The width of the belt required for pulley *A* we find, as explained before, by ascertaining the frictional surface of the same for the belt. Referring to Figs. 54 and 55 we find this surface to

be c' d'. We must, of course, examine the smaller pulley, as this has the smaller frictional surface. If we do not want to find this surface by drawing the plan, we can proceed as follows:

The total circumference of pulley A is $= d\,\pi$ = the arc of 360°, and to find the number of degrees for c' d', draw two vertical lines through the center of the shaft of each pulley A and A' to the line connecting both centers. We know that angles $o\ e\ c = o\ f\ d = o'\ e'\ c' = o'\ f'\ d' = w$, and drawing a line through e'



Pulleys for Power Transmission.



Pulleys and Belt.

parallel to oo' we know that angle $g\ e'\ e$ is also $= w$ as the sides of both are vertical to each other. Therefore

$$tan\ w = e\ g : b = \frac{R - r}{b} = \frac{32 - 24}{b},$$

and if $b = 240''$,

$$tan\ w = \frac{8}{240} = 0.0333,$$

and as per table of natural trigonometrical functions $w = 2°$, or, in this case, a very small one which we could have neglected and taken simply one-half of the periphery of pulley A. However, the angle wanted is $= 180 - 4$ and the arc $= \frac{180 - 4}{360} d\,\pi = 37''$, and expressed in parts of the radius $= \frac{37}{12}$.

The formula for the friction was $P = Q\, e^{mw}$, and to get P we have to insert the values m and w, and then the table of sizes of *belts and tensions* will give the required width of belt. $m = 0.1$[illegible] *for old greasy belts.*

SIZES OF BELTS AND TENSIONS.

b	2 In.	4 In.	6 In.	8 In.	10 In.	12 In.
d	[illegible] In.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
S	[illegible] lbs.	219	[illegible]	371	[illegible]	[illegible]
p	21 lbs.	41	60	80	100	124

We will call b = width of belt; d = thickness of belt; S = tension in the belt per square inch; p = tension of the belt per inch. We can allow $S = 77 \sqrt[4]{b^3}$, and $d = 0.147 \sqrt[4]{b}$, and $b = 0.31 \sqrt{P}$, if P is exerted at the rim of the pulley, and if the horse-power is given $= H$

$$b = 0.31 \sqrt{\frac{H\,33000}{2\,\pi R n}}.$$

$$\text{in which } H = \frac{2\,\frac{R}{12}P.n}{33000}$$

and R = radius of pulley in inches.

In a shorter form

$$b = 78 \sqrt{\frac{H}{nR}} = 78 \sqrt{\frac{25}{12 \times 100}} = 10.6''.$$

In order to have sufficient friction of the belt the value in the formula $P = Q\,e^{wm}$ for the factor e^{mw} must be at least $= 1$. Then $Q = P$. But in this case we have $e^{0.37} = 1.448$, or nearly 50 per cent more friction than necessary.

WIDTH OF OTHER BELTS.

For the width of the other belts we proceed as follows:

First, the consideration of the belt friction of which we can dispose in short order. Since the factor e^{mw} must be at least $= 1$ to prevent slipping, and we know that $e^{0.1} = 1.11$, or sufficient, then we need only examine the exponent mw, and if this is less than 0.1 we must either take a larger pulley or, if the arc can be sufficiently increased by crossing, the belt should be crossed, or tension S decreased by making the belt wider.

The width of the belts for pulleys B, C, D are b', b'', b'''.

$$b' = 78 \sqrt{\frac{5}{3 \times 100}} = 10'';$$

$$b'' = 78 \sqrt{\frac{8}{9 \times 100}} = 7.41'';$$

$$b''' = 78 \sqrt{\frac{12}{10 \times 100}} = 8.858''.$$

The moment at the periphery of pulley $A = \dfrac{25 \times 33000}{\frac{12}{12}\ 2\pi\ 100}\ 12 = 15756$,
or $P\ R = 15756$, in which $P = 1313$, and $R = 12''$.

To facilitate matters we can simply use the tensions in the table per one inch width, multiplying them by the width of belt selected to get P. If we make $b' = 10''$, $b'' = 8''$, $b''' = 10''$, we have these moments:

for pulley B $10 \times 100 \times 3 = 3000$ lb.",
for pulley C $8 \times 80 \times 9 = 5760$ lb.",
for pulley D $10 \times 100 \times 10 = 10000$ lb.".

It is not advisable to allow the angle of twist of a shaft to be more than $1°$ per $16'$ of length, and the table for lateral and torsional strength is figured on this basis. This table gives the diameter of different shafts for the given moment $= P\ R$, and for the quotient formed by dividing the number of horse-power through the number of the revolutions.

TORSIONAL STRENGTH.

Every shaft is subjected to two kinds of tensions, viz., the "lateral" tension or strength, and the "torsional" tension or strength.

As a rule, the torsional strength required is much greater than the lateral, and therefore it is best to look for this first. But it may be that the bearings are so far apart that the bending of the shaft by the force acting on the rim of a pulley, or the force acting at the teeth of a gear, requires a heavier shaft than is necessary for the torsional tension. This case will be considered later.

Of course, we must select the greatest force P acting on any of the pulleys, if the shaft is to have the same diameter all through. The greatest force, as we will see by comparing the four forces, is the force P acting at the rim of pulley A, and $= 1313$ *lbs.* *If* we find in the table under the head of *torsional strength* the value of $P\ R = 15756$ (nearest value $= 15770$), the

the diameter of the shaft needed is 3.4". This diameter we could reduce a little for pulley *D*, since there the moment is only 10,000 and this corresponds to a belt of 3.1, but it would hardly pay to do so.

SHAFT DIAMETERS FOR GIVEN MOMENT PR AND QUOTIENT N:n.

d In Inches.	For Lateral Strength. PR	For Lateral Strength. $\frac{N}{n}$	For Torsional Strength. PR	For Torsional Strength. $\frac{N}{n}$
1.2	2907	0.046	245	0.004
1.4	4454	0.071	453	0.007
1.6	6648	0.105	773	0.012
1.8	9468	0.150	1239	0.02
2.	12986	0.206	1888	0.03
2.2	17292	0.274	2704	0.044
2.4	22440	0.355	3915	0.062
2.6	27692	0.452	5303	0.085
2.8	35622	0.564	7258	0.115
3.	43830	0.694	9606	0.151
3.2	53109	0.842	12373	0.196
3.4	63800	1.01	15770	0.25
3.6	75720	1.199	19820	0.314
3.8	89064	1.411	24603	0.39
4.	108880	1.645	30206	0.478
4.4	138280	2.19	44225	0.71
4.8	179520	2.84	62650	0.99
5.2	228260	3.61	86290	1.37
5.6	285100	4.51	116100	1.84
6.	350500	5.55	152980	2.42
6.4	425360	6.74	198830	3.14
6.8	510230	8.08	252300	4.
7.2	605600	9.59	317100	5.02
7.6	712400	11.28	393720	6.24
8.	830820	13.16	483350	7.66
8.8	1105600	17.51	707620	11.21
9.6	1435600	22.74	1002300	15.88
10.4	1825200	28.91	1380500	21.87
11.2	2280000	36.11	1856500	29.41
12.	2804000	44.41	2447000	38.76

LATERAL STRENGTH.

If we now look in the column for the lateral strength we find much smaller shaft diameters, which, however, cannot be used in our case, as the torsional strength requires a shaft of greater diameter.

If we should find, however, that the lateral strength requires a greater diameter, in such case we must consider a combination moment formed from the two, the lateral and the torsional, which we will call $= W_r$; and the torsional moment $= M_t$, and *the lateral moment* $= M_l$. Then we have

$$\text{if } M_l > M_t\text{, then } M_r = 0.975\, M_l + 0.25\, M_t,$$

and

$$\text{if } M_t > M_l\text{, then } M_r = 0.625\, M_l + 0.6\, M_t.$$

If we have a shaft (Fig. 56) of the length l'' from center bearing to center bearing, and a pulley is placed between the two bearings at the distances a and b from the respective centers of bearings, then we have first the pressure exerted against the bearing at A;

$$P' = Q \frac{b}{a+b},$$

if Q is the load on the shaft and equal to the force acting on the rim of the pulley; and at point B,

$$P'' = Q \frac{a}{a+b}.$$

Then the lateral moment of the point where the pulley is placed must be equal to the lateral moment of each bearing, and to have equilibrium they must be both alike.

$$M_l = Q \frac{ba}{a+b} = Q \frac{ab}{a+b},$$

if the load is in the middle of l'', then

$$a = b \text{ and } M_r = Q \frac{a^2}{2a} = Q \frac{a}{2}.$$

DISTANCE OF BEARINGS.

If we make $l'' = 120''$ we can figure the M_r. If Q is in the center of the shaft, we have $P = 1000$ lbs.; $R = 10''$. Then

$$M_r = P R = 10000;$$

and

$$M = Q \frac{a}{2} = 1000 \times 30 = 30000; a = 60.$$

Therefore,

$$M_r = 0.975\, M_l + 0.25\, M_t = 0.975 \times 30000 + 0.25 \times 10000,$$

or

$$M_r = 29250 + 2500 = 31750,$$

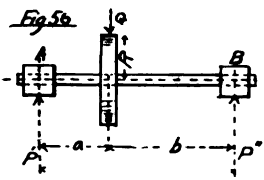
that is, far above the figure which we used when selecting the diameter of 15770. This shows that we must put the bearings closer together if we want to place a pulley with such moment in the middle of the shaft.

To find the proper bearing distance for a shaft of $3.4''$ diameter and the above pulley placed in the center

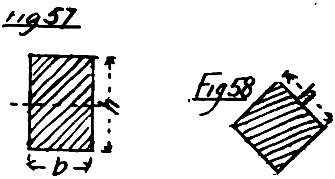
$$M_r = Q \frac{a}{2} = \frac{15770 - 2500}{0.975}; \text{ and } a = 27; \text{ and } l'' = 54''.$$

If we must make the distance between the bearings greater, and want the pulley in the middle, we must increase the diameter of the shaft so that the resulting moment is equal or less than the moment given in the table for the diameter of shaft selected.

If we want to know how far we can set pulley D away from the bearing without bringing undue lateral strain upon the shaft of the selected diameter, we have the moment of the force P''' acting on the rim of pulley $D = 1000$ lbs., and the lever of $P''' = a'$. Since we have no outer bearing we have only to consider this distance of the center of the pulley from the center of bearing $= a'$. The moment, therefore, $= P''' \times a' =$ the torsional moment $= 10000$; and since we know $P''' = 1000$, we find $a' = 10''$, that is, the pulley can be placed only $10''$ from the center of the bearing.



Transmission Shaft, with Pulley and Bearings.



Stresses.

If it is desired, however, to set the pulley farther away, making the distance $b = 120''$, we can find the distance a at which the next bearing must be placed to prevent undue strain of the shaft.

$$M_r = 15770 = 0.975\ M_l + 0.25\ M_t$$

$$= 0.975 \times 1000 \frac{120 \times a}{a + 120} + 0.25 \times 10000;$$

or,

$$15770 = 0.975 \times 1000 \frac{120\ a}{120 + a} + 2500;$$

$$13270\ (120 + a) = 975 \times 120 \times a;$$

$$13270 \times 120 = (975 \times 120 - 13270)\ a = 1592400 : 103730 = 15.2''.$$

If the distances are given in proportions of the whole distance, which is commonly the case, we must find the correct shaft *diameter* for the combination moment existing in the place where *the pulley is placed.* If we make the distance $l = 250''$, and $a = 4\ b$, we have

$$M_r = 0.975 \times 1000 \frac{50 \times 200}{50 + 200} + 0\ 25 \times 10000 = 41500\ lb''$$

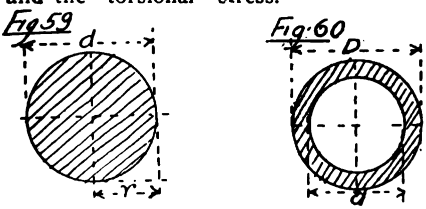
and find in the table for the nearest value $d = 4.4''$ = diameter of shaft required.

STRESSES.

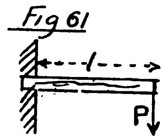
"Strength" of a material is its resistance to a permanent deformation.

"Elasticity" of a material is the amount of stress it can sustain and still regain its original form after the removal of the stress.

A body can be subjected to four principal stresses: The "crushing" stress, the "tensile" stress, the "transverse" stress, and the "torsional" stress.



Stresses.



Safety Modul.

1. The "Elasticity Modul" (E) is the number of pounds required to double the length of a prism of one square inch area, assuming that the elongation per pound of weight is the same after the body has been torn asunder as before this took place. It is proportional to the weight as far as it can be observed.

2. The "Strength Modul" (K) is the number of pounds which must be exerted to elongate the prism to the limit of its elasticity, that is to say, so that it will regain its original length after the load has been removed.

3. The "Load Modul" (T) is the number of pounds of weight required to tear the prism apart.

4. The "Safety Modul" (K') is the number of pounds which, experience has taught, can be safely exerted upon the prism without deforming it if subjected to it ever so often, as is the case practically. It is expressed in parts of the load modul, and the *symbol expressing it is* = m, therefore, $K' = \frac{T}{m}$.

We have two kinds of moduls for each of the above. O
gives the number of pounds for the pulling stress, and the otl
the number of pounds for the crushing stress.

MODULS FOR DIFFERENT MATERIALS IN POUNDS PER SQUARE INCH.

Name of Body.	Elasticity Modul E.	Limit of Elasticity for		T Strength Modul for		K Load Modul.		K' Safety Modul for	
		Pull ÷ E.	Crush ÷ E'	Pull.	Crush.	Pull.	Crush.	Pull.	Crush.
Larch Wood	1,700,000	$\frac{1}{400}$	$\frac{1}{533}$	4250	3188	15600	7800	1560	780
Pine Wood, white	1,700,000	$\frac{1}{800}$	$\frac{1}{666}$	3400	2550	13680	6840	1368	684
Oak Wood	1,600,000	$\frac{1}{470}$	$\frac{1}{546}$	3400	2860	11000	5500	1100	550
Pine Wood, pitch	1,600,000	$\frac{1}{536}$	$\frac{1}{714}$	3150	2230	11000	5500	1100	550
Wrought Iron	27,300,000	$\frac{1}{1250}$	$\frac{1}{1250}$	21840	21840	55000	44000	9030	7250
Iron Wire	30,000,000	$\frac{1}{843}$	$\frac{1}{843}$	35600	35600	89000	71200	14880	11770
Sheet Iron	24,600,000	$\frac{1}{1222}$	$\frac{1}{1222}$	20000	20000	49200	41000	8200	6840
Cast Iron	13,680,000	$\frac{1}{1562}$	....	8760	26280	19800	108000	3280	18200
Steel	34,200,000	....	....	....	....	108000	96000	18200	15870
Copper	15,000,000	$\frac{1}{4000}$	....	3750	....	34200	82000	5750	13680
Ropes	....	....	....	....	....	7000	....	....	....
Belts	....	....	....	....	....	....	....	270	....

If we call P the load or force in pounds; *L* the length in incl
of the body; l the elongation of the body suffered; E the elasti
nodul; F = cross section in square inches; we have for th

1. *Pulling stress:* $P = F\,K$, and $F = \frac{P}{K}$; and for practical purposes $P = F\,K'$; $K' = \frac{K}{m}$; $m = 6$ usually.

2. *Crushing stress:* $P = F\,K$ (crushing) and, practically, $P = F\,K'$ (crushing).

3. *Transverse stress:* To consider what will happen to a beam, when it is fastened at one end in the wall, and the load applied at the other end, we must consider the beam as a mathematical line, taking the neutral axis of the beam, in other words, the line of center of gravity for all cross sections existing. In the case of a regular wooden beam these cross sections are all alike, and the center of gravity of the cross sections lies in the center of it, and is found by drawing the two diagonals of the section, their point of intersection being the center of gravity for this special section.

In order to make the formula independent of the cross section of the beam we use a factor W which is obtained by dividing the bending modul $e\,W$ by the distance of the farthest fiber in the cross section from the center of gravity of the section, and called the section modul. Below are given some of the values W and $e\,W$ mostly used:

	shape	*area*	$e\,W$	W
Fig. 57..	*rectangular*	$b\,h$	$\frac{b\,h^3}{12}$	$\frac{b\,h^2}{6}$
Fig. 58..	*square*	h^2	$\frac{h^4}{12}$	$0.118\,h^3$
Fig. 59..	*cylinder*	$0.785\,d^2$	$0.049\,d^4$	$0.098\,d^3$
Fig. 60..	*tube*	$0.785\,(D^2 - d^2)$	$0.049\,(D^4 - d^4)$	$0.098\left(\frac{D^4 - d^4}{D}\right)$

SAFETY MODUL.

If we call P = weight in pounds; Q = load, or load and weight of beam; l = length of beam; a and b the distances where P attacks; W = section modul; K' = safety modul. We have for a beam fixed at one end (Fig. 61):

$$W\,K' = \left(P + \frac{Q}{2}\right),$$

$$Q = o;$$
$$W K' = P l.$$
$$P = o;$$
$$2 W K' = P l.$$

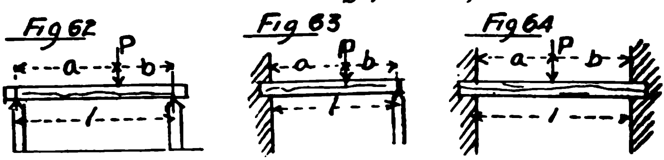
for beam supported at both ends (Fig. 62):

$$W K' = \left(\frac{P a}{l} + \frac{Q}{2}\right)^2 \frac{1}{2 Q}, \text{ if } \frac{P}{Q} < \frac{b - a}{2 a};$$

$$W K' = \left(P + \frac{Q}{2}\right) \frac{a b}{l}, \text{ if } \frac{P}{Q} > \frac{b - a}{2 a};$$

$$W K' = P \frac{a b}{l}, \text{ if } Q = o;$$

$$4 W K' = P l, \text{ if } a = b;$$
$$8 W K' = Q l, \text{ if } P = o;$$



Safety Modul.

For beam fixed at both ends (Fig. 64):

$$W K' = P \frac{a b^2}{l^3} + \frac{Q l}{12},$$

$$\text{if } a = b, \quad 8 W K' = \left(P + \frac{2}{3} Q\right) l;$$

$$\text{if } Q = o, \quad 8 W K' = P l;$$
$$\text{if } P = o, \quad 12 W K' = Q l.$$

For beam fixed at one end and supported at the other (Fig. 63):

$$W K' = P \frac{a b (a + 2 b)}{2 l^2} + \frac{Q l}{8},$$

$$\text{if } a = b, \; 8 W K' = \left(\frac{2}{3} P + Q\right) l;$$

$$\text{if } Q = o, \; \frac{16}{3} W K' = P l,$$

$$\text{if } P = o, \; 8 W K' = Q l.$$

Explanation of conditions:

$a = b$, means load or force in the middle of the beam.

$Q = 0$, means weight of beam neglected.

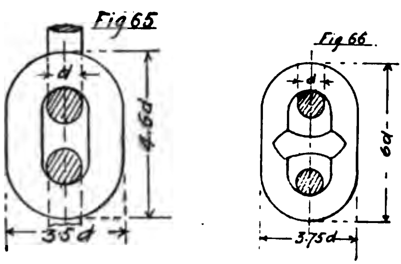
$P = 0$, means the load evenly distributed.

4. *Shearing stress* is a transverse stress acting in the plane of the force, tending to shear off the body at the attacking point of P. It is proportional to the cross section, and its modul is 0.8 of E, or 0.8 of K' for practical purposes.

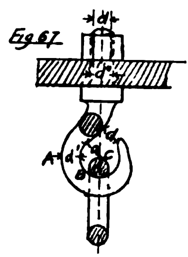
STRENGTH OF ROPES AND CHAINS.

Rope.—Diameter of rope $= d$. Then

$$P = \frac{d^2\pi}{4}\,\frac{K}{m};\quad K\text{ (pull)} = 7000\ lbs.$$



Strength of Ropes and Chains.



Strength of Hooks.

$$P = \frac{d^2\pi}{4}\,1400;\quad \frac{K}{m} = K' = 1400\ lbs.$$

$$m = 5 = \text{coefficient of safety.}$$

Wire Rope.—Diameter of rope $= d$.

$$P = \frac{d^2\pi}{4}\,\frac{K}{m};\ K = 89000,$$

and for wet rope

$$K' = \frac{K}{2.5} = 35600\ lbs.;\ m = 2.5.$$

and for dry rope

$$K' = \frac{K}{5} = 17800\text{ lbs.};\ m = 5.$$

16

Iron Chain.—Diameter of round iron used $= d$.

$$P = \frac{d^2 \pi}{2} \frac{K}{m} = P \frac{d^2 \pi}{2} K', K = 55000 \text{ lbs.},$$

but on account of the bending and welding necessary, make $K = 40000$, and for ordinary links (Fig. 65),

$$K' = 10000 \text{ lbs.},$$

for links with stays (Fig. 66),

$$K' = 12500 \text{ lbs.}$$

STRENGTH OF THE HOOK.

In Fig. 67 we call d = diameter of bottom of thread securing hook to fixed point; d' = diameter of round iron, of which the hook is supposed to be made, measured on center line AC of the hook $= AB$; CB the radius of the hook $= a$.

If we make $a = \frac{5}{6} d$, and $d' = 2.85\, d$, and since we know that the iron of the part d requires

$$P = \frac{d^2 \pi}{4} \times \frac{k}{m} = \frac{d^2 \pi}{4} \times \frac{55000}{6} = \frac{d^2 \pi}{4} \times 9000,$$

After we have obtained d we have to select d'' so that the thread will reduce it not more than to d at the bottom.

STRENGTH OF RIVETS.

Stress in the plane of the sheet.—In Fig. 68, if D = thickness of sheet; d = diameter of rivet; f = distance center rivets to end of sheet; e = distance center to center of two adjoining rivets; then

$$\frac{\textit{strength of joint}}{\textit{strength of sheet}} = \frac{1}{1 + \frac{4\,D}{\pi\, d}}.$$

This shows that the strength of the joint increases when the diameter of the rivets increases, as then the value $\frac{D}{d}$ is smaller. But if d is increased then e must also be increased, and this means that the rivets must be placed farther apart, and therefore, the tightness of the joint impaired, the joint loses in tightness *what it gains in strength.*

For joints which are required to be tight and strong at the same time take $\frac{D}{d} = 2$.

The resistance against tearing out the iron between the rivets $= (e - d)\, D\, K'$.

The resistance against shearing out the rivet holes at the end of the sheet $= 2\, f\, D\, K'$.

The resistance of the rivets against shearing off $= \frac{d^2\, \pi}{4} K'$.

And

$$\frac{e}{d} = \frac{\pi}{4}\left(\frac{D}{d}\right)^2 + \frac{D}{d},$$

$$\frac{f}{d} = \frac{\pi}{8}\left(\frac{D}{d}\right)^2.$$

Fig 68

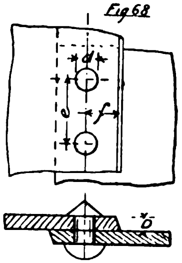
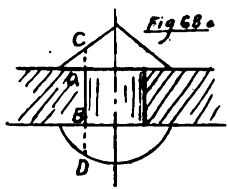


Fig 68a



Strength of Rivets.

If $\frac{D}{d} = 2$, then $\frac{e}{d} = 5.14$, for which 5 is taken, and $\frac{f}{d} = \frac{\pi}{2} = 1.57$, for which the working formula $f = 3d$ is used.

The strength of the joint of which $\frac{D}{d} = 2$, and $\frac{e}{d} = 5$, is equal to $\frac{3}{5}$ of the strength of the sheet before riveting.

Stress vertical to the plane of the sheet.—Under such stress the heads of the rivets may be shorn off (Fig. 68a). If $X = AC$ and $X' = BD$, then these represent the shearing lines, and we *must have* $x = \frac{d}{4}$ if the heads are to have the same strength as *the rivets with respect* to pulling apart.

[redacted]

The diameter of the conical head is usually $= \frac{3}{2} d$, and the diameter of the round head $= 2d$, and its height $= \frac{3}{4} d$.

STRENGTH OF BOLTS.

The diameter to be calculated is the diameter at the bottom of the thread $= d$. The area $= F$ is the one which we have to test for strength. $F = \frac{d^2}{4} \pi$. We have for wrought iron $K = 55000$, and take $m = 12$, on account of the twist the material has received while being threaded, and which it receives when the bolt is tightened. Therefore,

$$P = \frac{d^2}{4} \pi \frac{K}{12}, \text{ and } \frac{K}{12} = 4500.$$

The height of the head $= \frac{d}{4}$, and of the nut $= \frac{d}{2}$, is required to give the same strength, while in practical work the head is made $= \frac{3}{4} d$, and the nut $= d$.

STRENGTH OF CYLINDRICAL SHEET IRON VESSELS.

We call p the pressure per square inch of surface; d the thickness of the shell; m the coefficient of safety; r the radius of the cylinder; K the load modul. We have

$$d = \frac{m p r}{K},$$

and take $m = 12$, which is necessary to prevent parting of the sheet lengthwise.

$$d = \frac{m p r}{2 K},$$

is necessary to prevent the parting of the sheet crosswise, and is only half of the above.

This is independent of the form of the head. If the head is part of a globe, as is usual, and $d =$ thickness of head, and $r =$ the radius of the globe, then

$$d = \frac{m r p}{2 K}.$$

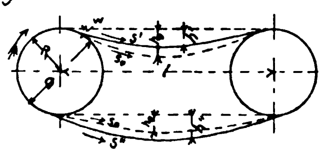
WIRE ROPE TRANSMISSION.

We call P the force exerted on rim of rope pulley; d the diameter of rope; S the tension of rope per square inch; i the number of wires in rope; D the diameter of rope pulley; f' the coefficient of journal friction of pulleys; f the friction coefficient of rope on pulley; R the radius of rope pulley.

This kind of transmission enables us to transmit power for long distances without much loss of efficiency. The distance possible is up to 4,000 feet. This is possible since the whole transmission requires nothing more than two rollers, and perhaps carriers over which the rope passes slack, and the weight of the rope furnishes the necessary tension.

Most of the ropes used for this purpose consist of six ropes twisted into one, each in turn being composed of six single wires, making a total of thirty-six wires with a rope core in the center.

Fig 69



Wire Rope Transmission.

If it is desired to make the rope still stronger for the same diameter, then the rope core is replaced by a seventh wire rope.

The tension in the taut rope is called T, and the tension in the slack rope t. Then the minimum P requires

$$\frac{t}{P} = 1; \frac{T}{P} = 2; \frac{T+t}{P} = 3; \frac{T}{t} = \frac{1}{2}.$$

The loss by slipping of the rope is about 0.02 per cent of the power expended. If d' = diameter of journal of pulley, make $\frac{d'}{R} = \frac{1}{16}$, and take for f' the value 0.1, and for f the value 0.24.

$$S < 25000 \text{ lbs. per square inch.}$$

The diameter of the pulley must not be smaller than the equation gives $\frac{R}{d} = \frac{14000000}{S}$.

V = velocity of rope per minute in feet should not be more than = 100'.

The smallest possible diameter of a rope, which can be used, is obtained when $S + s$ is constant, making $\frac{s}{S} = 2$, which corresponds to $S = 8400$ lbs., and to $s = 16800$ lbs., or $\frac{R}{d} = 833$.

The sag of the wire rope.—If the wire rope by its own weight is expected to furnish sufficient tension to prevent slipping, we must find the distance between the two pulleys so that the weight of the rope will be equal to the force transmitted (Fig. 69).

We call l the distance from center to center of pulleys in inches; h' the sag of the taut rope; h'' the sag of the slack rope; $h°$ the sag of the rope when at rest; S' the tension of taut rope; S'' the tension of the slack rope; $S°$ the tension of the rope when at rest. Then we have

$$\frac{h'}{l} = \frac{l}{155\,S'};\ \frac{h''}{l} = \frac{l}{155\,S''};\ h° = 0.67 \times h'' + 0.28\,h'.$$

We can now find the length of the rope, knowing the sag, which is the same for the slack and taut rope when at rest. If we assume that the rope forms an arc of a circle, which is for practical purposes sufficiently accurate, and we call the line connecting both ends of the arc, for our purpose $= l$, the distance between centers of pulleys, and take $h°$ for the height of the arc, then

$$r = \textit{radius of arc} = \sqrt{h°^2 + \left(\frac{l}{2}\right)^2}.$$

Calling the angle formed by the two radii connecting the two ends of the arc with the center $= 2\,w$, we have $\tan w = \frac{2\,h'}{l}$, and we find w in the table of trigonometrical functions.

Since $2\,r\,\pi$ is the circumference of the whole circle formed by radius r, and represents $= 360°$, we must take for the length of the rope the value $r\pi\,\frac{2\,w}{360}$. Wire rope of one inch diameter will weigh about 0.2 lbs. If we take $s = 8400$ lbs., we have $\frac{R}{d} = 833$, and if we want to transmit the force of 550 lbs. at the rim of the

pulley, we have $\frac{P}{S} = \frac{550}{8400} = 0.065$ square inch. We then find in table of "thickness of wire" at six wires per rope for the nearest value to 0.065; $d = 0.048''$, if we select a thirty-six strand wire, and since we have $\frac{t}{T} = 1$, we get

$$t = 550 \text{ lbs.},$$

$$\frac{T}{P} = 2,$$

$$T = 1110 \text{ lbs.},$$

and

$$h' = \frac{l^2}{155 \times 8400} = 700'',$$

and

$$h'' = \frac{l^2}{155 \times 4200} = 1400'',$$

$$h^0 = 0.67\,h'' + 0.28\,h' = 1134''.$$

Therefore, the length of the rope should be $= \frac{550}{0.2} = 2750''$ $= 230'$. The diameter of the rope we find from $0.065 = \frac{d^2}{4}\pi$; $d = 0.28''$.

THICKNESS OF WIRE AT SIX WIRES PER ROPE.

S. lbs.	S. lbs.	$\frac{R}{d}$	l=36	l=42	l=48	l=60	l=72	$\frac{P}{S}$
700	24300	571	0.0200	0 0184	0.0172	0.0156	0.0134	0.01160
1400	23600	588	0.0240	0 0220	0.0208	0.0184	0.0160	0.01590
2800	22200	625	0.0280	0 0260	0.0244	0.0216	0.0178	0.02166
4200	20800	667	0.0320	0.0296	0.0276	0.0248	0.0218	0.02880
5600	19400	714	0 0360	0.0332	0.0312	0.0280	0.0244	0.03582
7000	18000	769	0.0400	0.0368	0.0348	0.0308	0.0271	0.04406
8400	16600	833	0.0480	0.0444	0.0416	0.0372	0.0325	0.06080
9800	15200	909	0.0560	0 0516	0.0480	0.0432	0.0378	0.08720
11200	13800	1000	0.0640	0.0592	0.0556	0.0496	0.0432	0.11320
12600	12400	1111	0 0720	0.0664	0.0624	0.0556	0.0485	0.14322
14000	11000	1250	0 0800	0.0740	0.0692	0.0620	0.0539	0.17682
15400	9600	1429	0.0880	0.0812	0 0764	0.0680	0.0596	0.21560
16800	8200	1667	0 0960	0.0888	0.0832	0.0744	0.0649	0.25470
18200	6800	2000	0 0104	0.0960	0.0900	0.0804	0.0703	0.29904
19600	5400	2500	0.1120	0.1036	0.0968	0.0868	0.0756	0.33098
21000	4000	3333	0 1200	0.1108	0.1010	0.0928	0.0810	0.39780
22400	2600	5000	....	....	....	....	....	....
23800	*1200*	*10000*	....	....	....	....	....	....

$s = 25000 - S$ tension caused by bending wires around p

and since $\frac{R}{d} = 833$, it follows that $R = 0.28 \times 833 = 133''$.

We cannot, of course, use such distance of pulleys under nary conditions, unless the power is to be transmitted from hill, where the valley between has at least a depth of $h'' =$ $= 117'$. The power which we assumed transmitted is very and the rope, therefore, very light, and has to be long to the weight to 550 lbs.

In a case where we cannot allow such enormous sag, we use the rope like a belt, giving the rope tension by taking u of the sag, sufficient, as in the case of the belt, to prever rope from slipping on the pulleys.

We know that T must not be smaller than $2P$. If now increased m times, and the resulting tension called T^s, th $= m\ T$.

$$T^s = (2\,m - 1)\ t; \frac{t^s}{T^s} = \frac{2\,m - 1}{2\,m}.$$

The tension is to remain the same per square inch, the

$S^s = S' \frac{2\,m - 1}{2\,m}$, instead of ½ S', therefore the thickness

single wire $d^s = d \sqrt[3]{m}$.

The wire is under no extra strain, since we did not cha but took a larger diameter for each single wire.

POWER OF ANIMALS.

Name.	Force in lbs.
Man without machine	33
Man working on lever	11
Man working on crank	22
Man working on rope vertical	22
Man working on rope horizontal	55
Horse without machine	132
Horse working on goepel	146
Steer without machine	134
Steer working on goepel	67
Mule without machine	110
Mule working on goepel	67
Ass without machine	90
Ass working on goepel	31

:LECTRICAL POWER IN THE BREWERY AND M/ HOUSE.

TRANSMISSION OF ELECTRICAL POWER.

In late years the old style of transmission of power by me: f belts or ropes is gradually being replaced by electrical trai ıission by means of a dynamo, wires and motors. Most of t ıilures experienced in the use of electrical transmission ha een found to be due to improper construction of dynamos an ıotors when these machines were in their infancy, or, rather, i ıe experimental stage. At the present time, however, these part ave been perfected to such a degree that break-downs, etc., car e usually ascribed to improper or careless manipulation, rather ıan to faulty construction.

The chief advantages derived from the use of electrical trans- ıission lie in doing away with the troublesome belts and coun- :rshafts, which require unceasing care, and are a source of con- derable loss of power by friction; also in the greater safety om fire and consequent reduction in insurance rates. This ;s of power has been stated as averaging about 40 per cent of : power delivered by the engine, running even as high as 50 cent, while the manufacturers of dynamos and motors claim ıaximum loss of power of only 20 per cent, or a difference of n 10 to 30 per cent in favor of electric transmission and t.

further advantage is that power can be transmitted to almost distance, so that a machine, no matter how far it is situated the power engine, can be instantly brought into use, while belt transmission the whole line of shafts, countershafts and leading to it must either be run idle until this machine is or, if not running, must be started up to run this machine which takes some time and signaling to the engineer.

also does away with the former method of arranging chines to suit the best way of placing the line shafts and the different machines to be placed in the most economical s, thereby saving space and giving economy of arrange-

ost of the building can also be somewhat cheapened as :s, girders, etc., need not be made of extra strength to support the shafting, pulleys, etc.

Furthermore, the electrical system is neater and cleaner, in that dripping of lubricating oil is done away with.

The danger to workmen getting caught in gearings, belts, pulleys, etc., is very much lessened.

ADVANTAGES OF ELECTRIC LIGHT.

Regarding the advantages of electric lighting, it can be said that electric lamps present the following advantages:

Electric light attains the highest degree of intensity and illuminating effect in comparison with light from any other source so far utilized.

If calculated from the point of view of efficiency, electric light proves to be by far the cheapest, which is especially true in respect to arc light as compared, for instance, with petroleum or even gaslight.

The handling and treatment of electric lamps is exceedingly simple, convenient, safe and cleanly, the latter consideration being especially advantageous in a brewery and malt house.

The radiation of heat by an electric incandescent lamp is almost nil, and the danger of fire is consequently reduced to a minimum. Electric lamps may be carried from place to place as far as the length of the wire connecting them with the source of energy permits, and can be lighted and extinguished instantaneously. Electric lamps do not fill the surrounding air with more or less malodorous products of combustion.

Both electric power and light can be generated by the same dynamo, thus simplifying the whole arrangement.

NATURE OF ELECTRICITY.

The true nature of electricity in all its many aspects is not yet clearly understood and remains to be further investigated. Electricity may, although it is not a fluid as was formerly held, be compared to water, on account of a similarity of their flow, in the following way:

Water falling from a certain height can be utilized for accomplishing work, for instance, driving a wheel. If two tanks connected with each other at the bottom by a pipe are filled with water at different levels, the water from the tank having the higher level will naturally flow into the tank of lower level till both tanks will contain water at the same level. If electricity is substituted for water and a wire or conduit for the pipe, an

[redacted]

idea can be obtained of the similarity of the nature of an electric current. Electricity flows through a wire from a higher level to a lower, similar to water. In case of electricity, however, the term *potential* is used, instead of level, and it may be said that an electric current flows from the high potential to the low potential.

This justifies the electrical term of *difference of potentials* by the similarity to difference of levels of water in two tanks connected by a pipe. Through every cross-section of the pipe a certain quantity of water flows per second, and this quantity may be taken as the measure of the strength of the current. Similarly through every cross section of the wire or conductor there flows per second a certain quantity of electricity, and this quantity may be considered as the measure of the strength of an electric current. The quantity of water flowing through a pipe in a given time may be increased by increasing the pressure that causes the motion of the water, that is, by increasing the difference between the levels of the two connected tanks. Similarly the strength of an electric current may be increased by increasing the difference between its potentials.

As moving water, for instance a waterfall, may do work, such as to drive a mill, so likewise the electric current can be utilized for accomplishing work. As the difference in levels is the moving power of a waterfall, so a difference in potentials of an electric current is the electro-motive force. A fall of difference of potentials would consequently mean a decrease of the power of the current and vice versa.

The strength of the flow of water through a pipe depends partially on the size of the pipe. The larger the pipe, the greater will be the flow, and the smaller the pipe, the slower the flow, under similar conditions, owing to the decreased or increased friction. The friction is the resistance of the pipe to be overcome by the flow of water. An electric current sent through a wire or any other conductor meets with resistance like a current of water meets with friction in a pipe. There is, however, an essential difference between simple mechanical friction and resistance in the electrical meaning of the term. Friction depends on the shape of the surface of a body. If the surface is smooth, the friction is correspondingly small. It is the degree of unevenness *or roughness that increases* friction, not the nature of the pipe

material itself. It is quite different with the resistance of a conduit to an electric current. Different bodies conduct electricity in different degrees. Some, for instance copper, conduct electricity readily, others are poor conductors, while some do not conduct electricity to any appreciable extent, and are called insulators. Even good conductors of electricity offer some resistance to an electric current, as the smoothest surface does not do away entirely with friction. The conductivity and non-conductivity of bodies to electricity is somewhat similar to the conductivity or non-conductivity of heat.

RESISTANCE.

In calculating the flow of water in a pipe the friction must be taken into consideration. In the same way the quantity of electricity per second passing from one point of the circuit to another depends on the resistance of the wire or conductor between the two points, provided a constant difference of potentials is kept up between them. The amount of electricity passing a given cross section of the wire must become less in proportion as the resistance increases. This *resistance is measured by ohms.* An ohm is the resistance of a column of mercury 106.3 centimeters (41.9 inches) long and one square millimeter (0.0015 inch) in cross section. A pure copper wire 46.25 meters (151 feet) long and one millimeter (0.0015 inch) in diameter, has a resistance of about one ohm.

If the comparison be mentally repeated between the flow of water in a pipe and a current of electricity in a conductor, there will be no difficulty in comprehending the correctness of the following *Ohm's law:*

"The strength of a current flowing between any two points of a wire is directly proportional to the electro-motive force in the wire (difference between its potentials) and inversely proportional to the resistance between these two points."

The *law of resistance* may be expressed as follows: 1. The resistance of a conducting wire is proportional to its length. 2. The resistance of a conducting wire of given diameter and length depends upon the specific resistance of the material from which it is made or

$$\textit{resistance} = \frac{\textit{length}}{\textit{area of cross section}} \times \textit{specific resistance.}$$

FUNDAMENTAL UNITS OF ELECTRICAL MEASURE.

Fundamental or absolute units used for defining various electrical quantities are the centimeter for measuring length, the gram for measuring mass, and the second for measuring time. All other electrical units are derived from these fundamental units. Briefly, this system is designated as the C. G. S. (initials of centimeter, gram and second) system and their quantities are represented by the letters E. M. F. In practice, however, larger units are used:

Quantity to be Measured.	Name of Practical Unit.	Symbol	Number of C. G. S. Units.	Multiples of Units.	Submultiples of Units.
Electro-motive force.	Volt.	E.	10^8	Units.	Units.
Current.	Ampere.	I.	10^1	mega = 1,000,000	deci = 0.1
Resistance.	Ohm.	R.	10^9	myria = 10,000	centi = 0 01
Quantity.	Coulomb.	Q.	10^1	kilo = 1,000	milli = 0.001
Capacity.	Farad.	C.	10^9	hecto = 100	micro = 0.000001
				deca = 10	

An ampere is a current that will pass with E. M. F. (abbreviation of electro-motive force) of one volt through a circuit whose resistance is equal to one ohm, or a current that will deposit, in a suitable apparatus for electrolysis, 1.118 milligrams of silver out of a solution of nitrate of silver, or decompose 0.09321 milligrams of water in a second.

A *volt* is the E. M. F. of the end points of a one-ohm resistance through which a current of one ampere flows.

A *coulomb* is the amount of electricity that flows in one second past a point in a conductor carrying a current of one ampere.

In order to get an idea about what a *farad* means it is necessary to explain what an electric condenser is. It is an apparatus consisting of alternative layers of conducting sheets and insulating materials. The conductors are very close together, and the adjacent ones are charged with opposite kinds of electricity, one with positive, the other with negative. Their nearness to each other allows them to hold a larger quantity of electricity than they could if each were alone by itself. The purpose of such an apparatus is to collect and retain electricity. They may be aptly compared to a reservoir for collecting and keeping water or gas. *The quantity* of gas a receptacle may contain depends *in the first instance* on the pressure of the gas, and in the second

on the size of the vessel. In the same manner the quantity of electricity in a condenser depends on its size and the pressure of the electricity. The farad is, therefore, a condenser with a capacity to hold one coulomb of electricity at a pressure of one volt. Such a condenser would, however, be inconveniently large for a unit of measure and a *micro-farad* is used instead in practice.

The rate at which an electric current does work is called the *power absorbed* in the circuit. The product of the current and E. M. F. is the measure of that power and is called a *watt*. A watt is consequently the unit of electric power, the power absorbed by a circuit whose resistance is such that an E. M. F. of one volt causes a current of one ampere to flow around it. A watt is then a voltampere (V. A.), it is equal to $\frac{1}{746}$ of a H. P. One thousand watts are called a *kilowatt*. One watt is equal to 10^7 *ergs* per second. A *watt-hour* is the work done in one hour by a power of one watt.

Work or energy produced or expended is measured by the *joule or volt-coulomb*, and is equal to watts $\times$ time $= 10^7$ fundamental units.

KINDS OF ELECTRICITY.

There are four methods of generating electricity:

1. By friction, as in the frictional machine;
2. By chemical action, as in a primary battery;
3. By heat, as in the thermo-pile;
4. By magnetic induction, as in the dynamo.

Electricity generated by the first and third methods has found practically no commercial application.

The second, or chemical electricity is not used to generate light or power commercially, but finds application in furnishing electricity for telegraph work, telephones, electric bells and electro-plating. Electricity of this kind is generated by the chemical action of an acid or a chemical solution upon plates of carbon or metal, such as zinc, copper, silver or platinum.

The main reason these batteries cannot be used to furnish electric light and power is because they gradually get weaker and weaker in their action, and finally become inert. The current generated has a very low pressure, so that *many batteries*, or cells, would be required to supply even a *few electric lamps*, and to keep these cells in good order would

require constant care and attention in the renewal or addition of the chemicals, metallic plates, etc., since in the generation of the current the metallic plates are dissolved or eaten away by the action of the liquid until the latter becomes entirely exhausted.

The fourth method, or electricity by magnetic induction, is the kind now almost universally used for power, traction and lighting purposes. In its application the power is usually furnished by a steam engine—sometimes by water power—from which the power is transmitted to a dynamo or generator, in which the power is changed into an electric current. This current is then conducted to where wanted, either to an electric lamp for lighting purposes, or to a motor, in which the electricity is again converted into power, to be used where it is wanted.

DYNAMO-ELECTRIC MACHINE.

The principle of a dynamo can be understood after some idea is obtained of electro-magnetism and induction.

A magnet has two poles, one positive and the other negative; the similar poles repel, while the opposite ones attract each other. This power of attraction or repulsion is directly proportional to the square of the distance between the poles. The space where the magnetic force is acting is called the *field of force,* in which the *lines of force* are contained.

It may be added to this brief statement that the *flux of force* is the total number of force lines passing through a surface.

Magnets are of two kinds, the so-called natural and the artificial, or electro-magnets. Electro-magnets can be made a great deal more powerful than the natural ones and are therefore preferred in practice. The total number of lines, which this force causes to flow through a space is called the *flux,* and the flux per unit area of space is called the *induction,* and is denoted by B. The amount of the induction depends upon what material fills the space considered, or its *permeability.* Permeability is denoted by the letter μ, and signifies the ratio of the induction to the magnetizing force producing it. The permeability of a vacuum is taken as a unit. The *reluctivity* of a body or its specific magnetic resistance is the inverse of its permeability.

Mechanical work expended in continuously moving a wire in a

magnetic field can be converted into electric energy. All that is necessary is to cause a closed coil of insulated wire to rotate in front of a magnet. If this is done a current is produced in the coil, which flows around it, first in one direction and then in the opposite direction. In order to generate a current moving always in the same direction, it must be provided with a ring split in two halves, rotating with the coil. Rubbing against the ring are two plates of metal or brushes, one on each side, to these are attached two wires leading to the circuit in which the current is required. At the instant when the current in the coil is at the point of reversing, each brush is passing from a position, touching one-half of the ring to a position touching the other half, which its fellow has just left. The current this way becomes practically continuous. This rotation coil is called the *armature*. An armature is therefore that part of dynamo in which the current is induced. It is usually, although not necessarily, a moving part and is composed of insulated wire that cuts the lines of the magnetic force produced by the fields. This cutting induces a current in the coils. A dynamo-electric machine therefore is a machine that converts mechanical energy into electric energy by means of an electro-magnet and induction.

Use is now made to a great extent of currents which were not rectified and are called *alternating currents,* while the machines themselves are called *alternators.* An essential part of the modern dynamos is the so-called *field magnet,* consisting of an iron core solidly connected to an iron frame and having a number of insulated copper wires wound around it.

Another essential part is the *commutator,* consisting of a number of copper bars or segments, usually affixed radially around the shaft of the machine, each segment being thoroughly insulated by sheets of mica. Its function consists in changing the direction of the current. Brushes collect the current from the commutator. The brushes are made of copper wire, copper or carbon plates, placed in contact with the commutator. There are at present about a dozen types of dynamos, differing from each other in the construction of their various parts.

MEASUREMENT OF ELECTRIC QUANTITIES.

Galvanometer. This consists of a magnetic needle suspended so as to move freely inside of a coil. The needle takes up a posi-

[redacted]

tion or turns according to the strength of the current moving through the coil.

Electro-dynamometer. The construction of this instrument is based on the principle of the mutual action of two currents on each other. The currents to be measured are sent through two coils, one of which is fixed, and the other movable and suspended by a torsion head. When a current passes through, the force with which the coils attract each other is measured by the degree of torsion produced, and this is proportional to the square of the current. In the commercial application of electricity, however, a needle moving over a scale from which volts or amperes can be read off directly, is used. These instruments are called *voltmeters* or *ammeters,* and play about the same part in electric machines as pressure gauges in steam use.

Wattmeter. This is used when the power is to be measured directly.

Resistance is measured by an apparatus consisting of a battery of cells, a galvanometer and a number of coils whose resistance is known. The standard make of resistances usually consist of wire, made of an alloy of platinum and silver or German silver, and covered with silk and wound on bobbins, the whole being saturated with paraffin to insure insulation. The two ends of the coils are each connected to a brass block, and this block made so that it can be electrically connected to its neighbor by the insertion of a brass plug between them.

STANDARDS OF ELECTRO-MOTIVE FORCE AND RESISTANCE.

The differences in potentials, or electric levels, are measured by a voltmeter. These voltmeters, however, have to be calibrated by means of a standard of E. M. F. For this purpose primary cells whose E. M. F. is accurately determined, are used. Such is, for instance, the Latimer-Clark's cell adopted by the Chicago congress of electricians. It consists of two glass tubes connected with each other. In one of the tubes is contained an amalgam of pure mercury and zinc, and in the other, pure mercury having a layer of sulphate of mercury at the top. The cell is filled with a saturated solution of sulphate of zinc, into which a crystal or two of zinc sulphate is placed to prevent supersaturation. The tubes are hermetically sealed with paraffin wax, and the poles *formed by pieces of* platinum wires fused through the bottom c

each tube, in order to make a contact with the mercury. The E. M. F. of such a cell is about 1.35 volts at 15° C.

Measurement of Electric Energy and Power. A wattmeter contains two coils. One of them is a short, thick wire, and the other a thin, long wire. The current to be measured is sent through the thick, short wire, while the thin, long wire is connected to the two points, between which it is desired to measure the power developed. The deflection of the needle of the instrument is proportional to the product of the currents of the two circuits. As, however, the long wire has a great resistance, the current flowing through it is proportional to the difference of potential between its ends. The deflection, therefore, indicates the product of the current and electro-motive force, since electric energy is power multiplied by time. It can be measured by a wattmeter in which the needle carries a style. The current can be traced on a cylinder moved by clockwork, the area of the current traced measuring the total energy expended or absorbed.

A modern form of meter indicates the amount of current consumed, upon a dial by means of revolving indicators, and has an external appearance very similar to a gas meter. The current, in passing through the meter, acts upon an armature coil system, causing it to rotate. The shaft of this armature communicates by means of a system of wheels with the indicators so that the latter in revolving over a series of dials indicate the current consumed by the motor.

Accumulators are a necessary part of every well arranged electric plant. Their purpose is to collect or accumulate electric energy and store it up for use when required. They may be likened to reservoirs of water into which water is pumped and from which it may be afterward drawn at a constant rate. The nature of an accumulator is similar to that of an electric battery. A *battery* may consist of one or many cells in which plates and liquids producing electricity by chemical action, are contained. There are two elements, or plates, of different substances, and a liquid contained in every *voltaic battery*. A *primary* battery is one in which the elements are placed and used until worn out. A *secondary* or *storage* battery is a battery in which the elements are placed in the cell and first "formed" by the passage of a current through them. The cell is then said to be "charged," and can then be used to supply electricity.

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ccumulator is on the whole nothing but a storage battery. ert plates are partially surrounded by a fluid incapable of chemically on either of them, until the passage of an current, after which they acquire the property of furnish- independent electric current.

CHARGING AND DISCHARGING ACCUMULATORS.

liquid for filling the cell must be distilled water to which ılphuric acid is added till the specific gravity of the mix- 1.190 when cold. The specific gravity should be 1.20 to ıen the cells are fully charged. The acid solution should into the cells to a height of not less than half an inch he tops of the plates, and this level should be kept con- ther by the addition of pure water or weak acid, so as to n this specific gravity. The current should not exceed ue for which the cell is constructed. The charge is not e until violent ebullition of the gases evolved has pro- for some time. The battery should always be kept as ıarged as possible. If the battery has been out of regular some time it must be *surcharged* for about 23 hours sub- to the time it is apparently fully charged.

ıormal rate of discharge should not be exceeded or should ıe continued after the specific gravity of the liquid has ed to below 1.17, or the terminal voltage of a cell to be- volts as the full rate of discharge.

ırging should be done immediately after each discharge.

THE ELECTRIC PLANT.

electric plant consists of two parts—the motor part, ıng mechanical energy, and the electric part, furnishing energy transformed from the mechanical energy. The ımmon source of energy in an electric plant is the steam The chief requirement for such an engine is the highest uniformity and regularity of operation. The best for rpose are compound engines.

ı a brewery or malt house electric power and light are d continually day and night throughout the entire year, engines are not running at times, especially in small es, the value of an accumulator from the economic point *seems obvious.* An accumulator should be chosen of

such a size as will supply about one-third of all the power required by the. plant.

ARC LIGHT.

As arc lights are sometimes used in breweries and malt houses a few words should be said about them. The principle of their construction is somewhat different in the three principal types of arc lights.

In the *series arc lamps,* the regulator consists of a bobbin of wire, having an iron core, the whole of the current passing through the lamp and the coil of wire. The iron core being more or less thoroughly magnetized, regulates the distance at which the carbons are held apart. The carbons themselves are electrically connected to two terminals on the top or bottom of the lamp. The carbons are kept touching when the lamp is out of use by their weight or a spring, and when a current passes through them, they are drawn apart and the arc is established.

In the *shunt regulating lamps* the regulating coil is placed as a shunt across the terminals of the lamp, and is made of a number of turns of fine wire so that only a small portion of the current of the lamp passes through it. This regulator cannot act when the potential difference is constant.

The *differential regulator* forms a combination of both systems, being supplied with both shunt and series regulating coils, which determine by their mutual action the distance of the two carbons. The electric arc requires 40 to 50 volts to keep it going.

The E. M. F. generated by the dynamo supplying the current must be sufficient to overcome the resistance of each separate lamp, as well as that of the conductors joining them. The dynamo must, therefore, generate currents at a high pressure. In order to avoid this useless resistance, causing a loss of energy, machines have been designed to produce a constant potential independently of the resistance of the circuit.

INCANDESCENT LIGHT.

The incandescent lamp consists of a glass globe, from which the air has been exhausted, and containing a carbon filament with *platinum tips,* which pass hermetically sealed through the end *of the bulb.* The platinum tips are usually passed through a

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short brass tube, cemented to the glass with plaster of Paris. Passing through the plaster the platinum wires are soldered to brass contacts imbedded in it. The purpose is to prevent the platinum wires, when they emerge from the glass, from breaking off and making the lamp useless. On opposite sides of the brass tubes are two small brass pins, which fit into slots in the lamp-holder, and thus form an easy method of detaching and removing the lamps. There are also two small spring blocks inside the lampholder, connected with the source of the current, which press against the contact blocks in the plaster of Paris, thus completing the electrical connection.

The equipment of a lamp is completed by a *switch* and *cut-out*. The switch is to turn the light off or on, or to break or restore the current to the filament. The cut-out is a device for insuring greater safety from the overheating of the wires leading to the lamps. It consists essentially of a thin piece of wire, made of a fusible alloy, placed in the lamp circuit. This fusible wire is made of such thickness, that if the current in the circuit becomes too dangerously strong this fusible wire or *fuse* becomes hot and melts and interrupts the current. Every lamp and coil system of lamps ought to have separate fuses.

STEAM ENGINES.

There are two kinds of steam engines, the "portable" and the "stationary" ones.

PORTABLE ENGINES.

The portable engines are generally connected to a boiler, complete, so as to be ready for immediate use, furnishing a convenient means of power at any place and whenever wanted.

Small sizes are mounted on a platform with axles and wheels, and upon the platform is erected a vertical boiler with an horizontal or vertical engine, steam connections and feed pump complete.

For use on farms for threshing, plowing, etc., a combination of an horizontal boiler, provided with axles and wheels, is used, the horizontal engine mounted on the back of the boiler, and the wheels moved by a chain connecting the wheels with a pulley on the shaft.

"Semi-portable" engines are made by putting an horizontal or vertical boiler upon skids, and, in the case of the horizontal boiler, mounting the horizontal engine either on the back of the boiler or on the skids, or, in the case of a vertical boiler, a vertical engine on the same skids with the boiler. The outfit is then either loaded on a low truck or moved by rollers to the desired place.

STATIONARY ENGINES.

Stationary engines are built vertically and horizontally, and for high and slow speed.

All "Corliss" and "automatic cut-off" engines are of necessity slow speed engines, as there is a limit to the rapid succession of cut-offs regulated by the governor, and such engines are generally not run faster than 50 to 120 revolutions, according to the size.

SLIDE VALVE ENGINES.

A "slide valve" engine can be constructed for a speed as high as 400 to 500 revolutions, and such engines are especially adapted for running dynamos, as the belt can connect directly and no countershaft is necessary, requiring less space, and even if the economy is not very great, the reduced first cost and the saving of the countershaft and belting is a great offset for this.

It is, of course, easy to understand that an engine running 400 revolutions, furnishing the same power as another engine running only 100 revolutions, can be almost one-quarter as light, and consequently will cost much less.

High speed engines generally have slide valves either flat or cylindrical, and have so-called fly-wheel governors, as the regular ball or spring governor would not be sensitive enough. High speed engines are mostly enclosed, the shaft, journals and crank running in oil, as very good and continuous lubrication must be furnished to prevent heating. A few of these engines are the Ideal, Westinghouse, Huse, etc.

Where there is no high speed required, as for drilling wells or hoisting, it is by far best to use slow speed engines, as in this case no countershaft would be needed.

There are a good many cheap and reliable upright engines in the market up to about 25 horsepower. When the power required is above 25 horsepower, it is economical to use a Corliss engine.

The slide valves are made either to close and to open a single port at one end of the cylinder, or two or more. This is done in order to get a quicker and larger steam opening with the same throw of the eccentric. Borsig of Berlin, Germany, used to build engines of this type.

A slide valve with an expansion slide on top and regulated by hand, gives very good economy for regular loads, and nearly as good a cut-off as the Corliss engine, the only difference being the large clearance in the main valve and the cylinder ports.

Meyer Cut-off.—For each valve there must be one eccentric set at a different angle, the main valve acting like an ordinary slide valve, while the two expansion slides can be adjusted by hand from the outside by operating a hand-wheel fixed to a screw passing through two nuts in the expansion slides, moving the slides apart or bringing them together. This cut-off is called

the "Meyer cut-off." In this case the cut-off can be regulated only by hand. But if placed in a separate steam chest on top of the main steam chest, the expansion slide can be operated by the governor, as it is independent of the motions of the main valve.

In some cases it is objectionable to have so much friction by the valve on the seat, so the valve is constructed balanced, by placing the flat valve between the seat and steam chest cover, without any play, or by using a cylindrical valve. But the trouble with either arrangement is that careful adjustment is needed from time to time.

The Rider Cut-off is similar to the Meyer cut-off. It has a main slide valve, and the back of it is formed like a cylinder with the center in the line of the slide-valve rod. In this cylindrical recess is placed the cylindrical expansion slide, which can be turned by its shaft around the axis, allowing more or less steam-opening as it passes the oblique ports of the main valve. This expansion slide is turned by a connection from the governor.

CORLISS ENGINE.

Corliss Cut-off.—The cut-off used most is the "Corliss cut-off," having cylindrical valves, the segments of which are pressed against the seats by the steam pressure, and act like regular slide valves as long as they are held by the valve stem. As soon as the governor disconnects the connection between valve and valve stem, the valve drops very quickly, actuated by a lever and vacuum dash-pot closing the steam inlet. When the wrist plate or the eccentric, which are connected together, reaches the end of its stroke, the connection is made again, and the valve laps until the time of steam admission when it opens the port and finally the valve is tripped again by the governor. This arrangement enables the use of long, narrow ports, with little depth, and consequently little clearance, the ports being only the thickness of the material forming the cylinder at the highest part of the bore and close to the ends and vertical to the center line of the cylinder. The live steam valves are on top, and the exhaust valves on the bottom, to drain off all condensed water.

Any engine over 25 horsepower should be a Corliss engine, and all engines under 25 horsepower, good slide-valve engines, *provided, if possible*, with automatic cut-off governor.

The most economical way, however, is to provide one large

and one smaller Corliss engine, compound condensing, one for use in the daytime, and the other at night, or for elevator and other occasional uses. Since nowadays every brewery has a refrigerating machine, there is generally enough water for condensing the steam on hand, if the water, after leaving the ammonia condensers, is not used for condensing the steam for the engine belonging to the refrigerating machine itself.

If sufficient water is not at hand for both the refrigerating machine and steam engine condenser a water cooling tower (which see) should be provided. All engines, boilers and pumps should be placed closely together, thereby saving time of the engineers, fuel and piping.

The Corliss engine has only one drawback, namely, that its valves are not absolutely tight, and this is because the cut-off being automatic and controlled by the governor, it is evident that the cut-off must vary continually, which means that the inlet valve does not travel over the same place in the valve chamber all the time. As long as the work and the revolutions are nearly constant, the variation will be only slight, but when these conditions are changed, as for instance, during beer cooling, where more revolutions and more power are generally required, the latter, owing to the higher suction and greater condensing pressure, the travel of the valve is materially changed, and it will travel farther, passing the point of the seat at which it formerly stopped.

It is clear that after the valve has traveled for some time over the same stretch, it has worn this place somewhat, and if it then travels beyond the place worn down, it cannot be tight on the seat, but will allow steam to leak into the cylinder after the cut-off has taken place, which, of course, involves a loss.

The slide valve, on the other hand, always travels over the same path, and since its edge travels both ways over the edge of the seat, the seat cannot wear a shoulder, and will, even if not quite tight in the beginning, soon become absolutely tight.

The desire to combine this advantage of having a reliable valve, and yet using the steam expansively, led to the construction of the "automatic governor," of which the only practical type is the "Trempor governor." This governor takes the place of the ordinary throttling governor, and gives just as quick a cut-off *as the Corliss,* showing as perfect speed regulation as the

Corliss governor and valve, besides being cheaper. The only disadvantage is that the clearance in the cylinder is somewhat increased because the steam is cut off before it enters the steam-chest, adding the contents of the latter to the cylinder clearance. When designing an engine for this governor this clearance can be greatly reduced, making the economy of such an engine almost as great as that of a Corliss engine.

USING STEAM EXPANSIVELY.

The advantages of using steam expansively instead of throttling, will appear from the following deductions:

In a throttling engine the speed of the machine is regulated by reducing the pressure of the live steam to suit the requirements, which may be up to one-half of the total pressure. We, therefore, do not get the benefit of the high boiler pressure, although we gain a little by superheating the steam, which is done by the reduction in pressure, at the same time reducing the steam cylinder condensation.

But another great objection to this kind of engines is that it is necessary to fill the cylinder about three-fourths with steam—three-fourths is generally the cut-off a slide valve has—while in an engine using the steam expansively there is, in the first place, steam of full pressure, and secondly, the cylinder need be filled only about one-fourth of its capacity.

There is another difference in the cut-offs of the two kinds of engines. The one provided with the slide valve cuts off very slowly, the valve being actuated by the slowly moving eccentric, while in the other case the vacuum under the dash-pot piston closes the valve rapidly. The process in the slide-valve engine can be called only a throttling, and the pressure is almost the same during the whole stroke.

DIFFERENCES OF THE TWO KINDS OF ENGINES.

The differences in the use of steam for the two kinds of engines are not inconsiderable. In the formulæ that will be given the steam cylinder condensation will be neglected. This condensation may amount to a little less in the slide-valve engine, owing to the lower temperature of the steam entering the cylinder. But since it is here assumed that both engines exhaust into the atmosphere the temperature will be the same during the exhaust period, and the difference will be small.

Taking the case of 100 pounds boiler pressure, and 90 pounds pressure at the cylinders, further assuming that the steam in case of the slide-valve engine is throttled to 60 pounds, the cut-off in the slide-valve engine being three-fourths, and in the Corliss engine one-fourth, in that case, for the mean effective pressure in each case, the general formula is:

$$p = P\ (ln\ P' - ln\ P + 1) - C,$$

wherein: p = the effective mean pressure; P' = the absolute admission pressure; P = the absolute final pressure at end of stroke; C = the absolute pressure of the exhaust; ln = hyperbolic logarithm.

The value P will be found through the proportion $P : P' = V' : V$, wherein V' represents the volume admitted before the cut-off takes place and V the volume at the end of the stroke.

Calling V, which is really the capacity of the cylinder, $= 1$, we, therefore, have for P in each case:

$$P = \frac{P'\ V'}{1} = (90 + 15) \times \tfrac{1}{4} = 26.25\ lbs.$$

$$= (60 + 15) \times \tfrac{3}{4} = 56.25\ lbs.$$

and therefore: For the automatic cut-off

$$\begin{aligned} p &= P\ (ln\ P' - ln\ P + 1) - C. \\ &= 26.25\ (ln\ 105 - ln\ 26.25 + 1) - 15. \\ &= 26.25\ (4.6540 - 3.2675 + 1) - 15. \\ &= 62.64 - 15 = 47.64\ lbs., \end{aligned}$$

and for the slide valve

$$\begin{aligned} p &= 56.25\ (ln\ 75 - ln\ 56.25 + 1) - 15. \\ &= 56.25\ (4.3175 - 4.0298 + 1) - 15. \\ &= 66.38 - 15 = 51.38\ lbs. \end{aligned}$$

If we admitted, therefore, in one case, one-fourth of a cubic foot of steam at 90 lbs. gauge pressure, and, in the other case, three-fourths of a cubic foot at 60 lbs. gauge pressure, we have for the respective weights of steam admitted:

$$0.2414 \times 0.25 = 0.0603\ lbs.,$$

and

$$0.1759 \times 0.75 = 0.1319\ lbs.$$

Or, allowing for the somewhat higher mean pressure in case of the slide-valve, we find that we use about twice as much steam for the latter as for the expansion engine.

This shows clearly the advantage of using the steam expansively.

SETTING THE VALVE.

The conditions to be observed in setting either valve are these: The valve should open before the end of the exhaust period so as to have a free passage for the steam when the piston is at the end of the stroke. It is not desirable to have the valve too wide open, one-sixteenth to one-eighth of an inch being generally sufficient, as the piston moves very slowly at this time, and a small opening allows sufficient steam to enter the cylinder at full pressure. The indicator card shows this plainly. If the admission line is an horizontal line with a sharp corner at the beginning, the admission is good; if not, the lead of either the valve or the eccentric must be increased. Which of the two should be done, can only be ascertained by examining the cushion of the exhaust.

DEGREE OF COMPRESSION.

If indicator cards can be taken, the compression curve at the end of the exhaust period should rise nearly to the steam admission line if the clearance is about 4 per cent, and to one-half the height if the clearance is 10 per cent.

In order to draw the expansion curve and to criticise the indicator card, the clearance expressed in parts of the stroke must be added to the diagram. If, for instance, the clearance in a slide-valve engine, figuring the space between the piston and cylinder head when the piston is at the end of its stroke, the space in the admission port of this side, and the clearance in steam chest, is 10 per cent, and the base line of the diagram, as taken from the cylinder, is 5" long, then half an inch must be added to the base line on either side to show the influence of the clearance. Vertical lines erected at the ends of the new base line will show the real amount of steam admitted, and are needed to examine the expansion line. Under no circumstances should the live port be open while the exhaust steam port remains open.

If there is no indicator at hand, the knocking of the machine will generally tell whether there is sufficient compression or not.

SETTING THE ECCENTRIC.

When setting the eccentric it should be remembered that the highest point of the eccentric body must advance the crank at *least 90° in the direction* the machine is to turn. To this must *be added the angle of* lead desired for the eccentric, and, of

course, in the same direction. This angle of lead, for slide-valve engines, is generally 15°, and for Corliss engines 25°.

If the sides of the cranks are parallel it is best to place the crank first in the horizontal position by using the spirit level, and then to turn the crank the way the machine is run, until a level provided with angle attachment, set to the proper angle, indicates that the crank has been moved the desired number of degrees over the center, when the highest point of the eccentric body should stand vertically, either above or below the center of the shaft, according to the way the machine is running.

If no such angle level is at hand, a wooden wedge can be made to take the place of it. Take a piece of wood about twenty-four inches square, and draw a circle of ten inches diameter on it. Draw two lines through the center, vertical to each other, and divide one-quarter of the periphery into ninety parts; or, if the angle desired is a figure ending with a 5 or 0, into 18 parts each of these representing 5°. If the angle desired is 15°, draw a line through the center and the third division, and cut the wood along this line and the center line next to it. This will give the desired angle, and is always ready for use in connection with an ordinary spirit level.

It is advisable to set the eccentric this way so that its position can be controlled in case it has slipped, without removing the steam chest cover.

The admission line cannot be allowed much higher than in Fig. 1, although it would be economical, as with 10 per cent clearance there would be too much cushion.

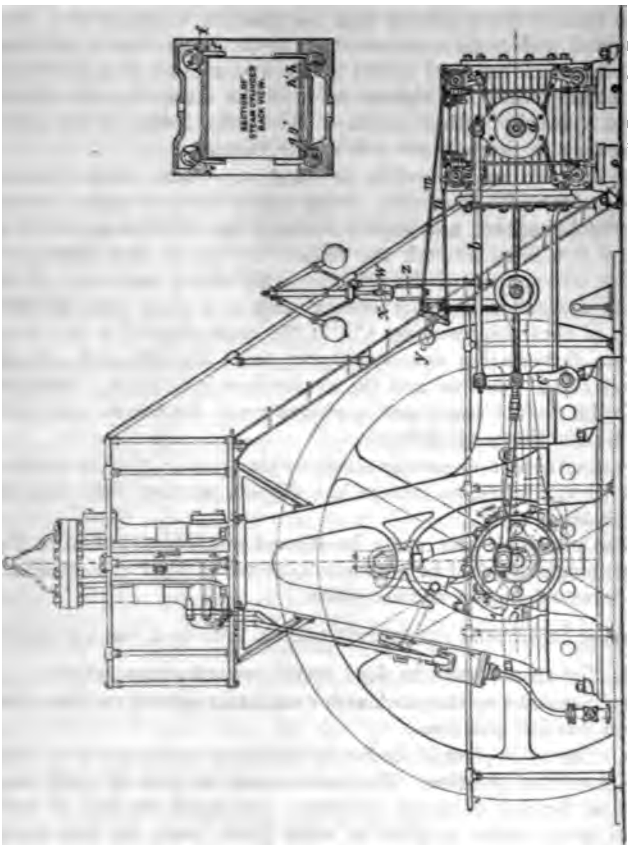
GENERAL DIRECTIONS FOR SETTING VALVES, ETC., OF A CORLISS ENGINE.

1. Set steam crank in dead center toward steam cylinder.

2. Set rod *a* so that rock arm *c* oscillates equally on both sides of its vertical position.

3. Set wrist plate *d* so that it oscillates equally on both sides of its vertical position. There are marks on hubs of wrist plate and on bracket of steam cylinder. The mark on hub of wrist plate gives center position of wrist plate, while the two marks on hub of bracket give the distance to either side of the vertical position which the mark on the hub of the wrist plate is to travel.

4. Set edges *e* and *f*, which are indicated by incisions on the back end of the live steam valves, so that they show a lap of given length in the direction opposite the arrows over edges *e*, and *f*, marked by incisions on the back end of the valve openings



Corliss Engine.

on cylinder. The length of lap is to be measured on the outside circumference of the valve.

5. Set edges g and h, which are indicated by incisions on the *back end of exhaust* valves, so that they show a lap of given

length in the direction opposite to the arrows over edges *g*, and *h*, marked by incisions on the back end of the valve openings on cylinder. The length of lap is to be measured on the outside circumference of the valve.

6. Turn highest point of eccentric or pin on governor pulley to its upper position, as shown on drawing. Then turn the eccentric as arrow points until the live steam valve *v* and exhaust steam valve *s* show the correct lead respectively. The lead in both cases is measured on the circumference of the valves in the direction as the arrows point. This completes setting of eccentric, rock arm, wrist plate, and live and exhaust steam valves, as far as it can be done without the use of an indicator.

7. Below is given a table showing the lap of live steam valves; of the exhaust steam valves; the lead of the live steam valves, and the angle of lead of eccentric:

Diam. of steam cyl.	12	16	18	20	22	24	28	32	36
Lap of live st. valve	$\frac{1}{4}$	$\frac{9}{32}$	$\frac{9}{32}$	$\frac{5}{16}$	$\frac{5}{16}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{5}{8}$	$\frac{5}{8}$ in
Lap of exhaust steam valve	$\frac{7}{32}$	$\frac{7}{32}$	$\frac{7}{32}$	$\frac{7}{32}$	$\frac{7}{32}$	$\frac{3}{16}$	$\frac{1}{8}$	$\frac{1}{16}$	$\frac{1}{16}$ "
Lead of live st. valve	$\frac{1}{16}$	$\frac{1}{16}$	$\frac{1}{16}$	$\frac{1}{16}$	$\frac{1}{16}$	$\frac{1}{16}$	$\frac{1}{16}$	$\frac{1}{16}$	$\frac{1}{16}$ "
Angle of lead of eccentric	25°	25°	25°	25°	25°	25°	25°	25°	25°

It might be best, after having set the valves according to instructions, to see whether the angle of lead obtained on eccentric or governor pulley corresponds to the angle of lead given in the table. It will be found a very useful check for the correct setting of the machine. It is further advisable to see whether, when the exhaust valves are just on the point of opening, the live steam valves still show a lap, so as to prevent any blowing off of live steam.

8. Set the horizontal weight bar *y* of governor so that it oscillates equally out of its horizontal position when the governor balls are brought into their highest and lowest position.

9. A ring with a notch or a pin is provided on the governor, by means of which the governor can either be placed in a position ready for regular running or for starting. When the machine is to be started, the steam cylinder must be able to receive the full steam pressure, and the live steam valves must not be tripped. When the machine is set for regular running, the governor bar *w* must be able to sink below the upper edge of the

ring x into a slot. If the belt should break when the governor is in this position, the governor regulating rods m and n will place two safety toes in such a position that the live steam valves will be permanently unhooked, and, of course, the machine stopped. In case a pin is used and the pin is removed, the governor can sink down sufficiently to allow the rods m and n to perform the same service as mentioned above. When it is desired to start the machine, the ring x or the pin which performs the same service must be placed so that the safety toes are put out of action.

10. Set cut-off toes on live steam valves so that they do not cut off when the governor is set for starting and so that they do cut off when a piece of wood or iron of about a quarter of an inch thickness is put upon the ring x or corresponding pin. The toes must be adjusted so that the live steam valves will be disengaged after the steam cross-head has traveled the same lengths of stroke from the dead centers. The toe of valve u must disengage when the steam cross-head has traveled (say for instance ⅜ of a stroke) from its dead center furthest from steam cylinder, and the toe of valve v must disengage when the steam cross-head has traveled the same distance from its dead center nearest steam cylinder.

11. Set safety toes so that they will not touch the disengaging point of lever when machine is set for starting, but will fully and securely disengage the live steam valves when the ring x is turned or the pin is taken out for regular running (the governor, of course, is at rest).

12. The dash pots be set so that their center is in a position just in the middle between the position given by dropping a plumb-bob from center of dash pot rod pin when this pin is in its highest or lowest position and when pin is horizontally opposite its center.

13. A by-pass valve is provided in governor dash pot which, when open, will allow the governor to move up and down freely, but when closed will retard the up and down motion of the governor. The dash pot should be kept full of a not too heavy oil all the time, or the governor will make this up and down *movement in jerks* corresponding to the height of the dash pot *not occupied by the oil.*

14. Set length of dash pot rods so that when the wrist plate is in its extreme position to the left the cut-off toe of valve *v* is in the middle of both stops provided on its disengaging lever (the first stop is the one which lifts the dash pot piston; the second stop is the one which will bring the dash pot piston to its lowest position in case the dash pot piston should not have reached this position of its own accord) and when the wrist plate is in extreme position to the right the cut-off toe of the valve *u* is in the middle of both stops provided on its respective disengaging lever.

15. The dash pots must be kept oiled through an oil inlet, which is provided, but it must be remembered that too much oil might cause a breakage of parts of the dash pot, as soon as the oil cannot escape quick enough through the compressed air passage when the dash pot piston drops.

A cushion regulating valve is provided, which must be set so that the dash pot piston does not strike the bottom of the dash pot too hard, and must still be far enough open to allow the dash pot piston to drop sufficiently so that the lifting toe and disengaging lever can engage the dash pot piston.

A vacuum breaking valve or cock is provided, by means of which the vacuum which facilitates the dropping of dash pot pistons can be regulated at will. Should the piston descend too quickly the valve or cock must be opened very little to obtain the desired speed. When running the machine with full pressure steam (not cutting off) the cock should be full open so that no extra strain is put upon the live steam valve by the dash pot. The dash pots should sometimes be cleaned, and if this is not possible, oiled with kerosene instead of lard oil, so as to prevent the sticking of the dash pot piston in the dash pot, which will take place mostly when the machine is started after it had been stopped for some time, and which prevents the engine working properly. A little pushing with the hand and some greasing may bring the dash pots in perfect working order in a few seconds.

Before starting the machine for the first time, the cylinder should be blown out thoroughly by steam so as to remove all sand or chippings which might be in the ports or cylinder, and for this purpose the back head and steam piston must be removed.

It must always be remembered that if the belt, which drives *the governor, is not* sufficiently tight, the governor cannot regu

late properly. Any slip of the belt on the pulleys will be noticed by irregular running of the machine.

When running a machine the first couple of days, it will be found advantageous to run it without cut-off, but under throttle; this while the governor and dash pot are connected, however.

The steam valves, which warp somewhat when heated, create considerable friction by grinding themselves in place and grunt, and when the steam pressure is reduced by throttling, it will be found that the engine and valves and dash pots work much easier, and that everything will be in first-class order much sooner than when cutting off.

EXAMINATION OF ENGINE AND COMPRESSOR BY TAKING INDICATIONS.

It is impossible to know, without an indicator, whether a steam engine uses the steam economically or not. The indicator will further tell whether the valves are set right or not, if good steam admission is had, if the cushion is proper and if the cut-off is even. The indicator will also tell if the piston or a valve leaks, and is the quickest means, and can be applied without stopping the engine, to find the trouble if the cylinder does not work properly.

The same holds good for ammonia compressors and pumps. All of them should be provided with openings for attaching the indicator, and provision should be made for attaching the indicator cord to the cross-heads.

The best for the purpose is an aluminum indicator, since it can be used for ammonia, as well as for steam. Further, a reducing pulley directly attached to the indicator should be had, so as to accommodate all strokes of engines and compressors and pumps of the brewery. Such a set can be had complete in a case. If the connections are permanently made to the cylinders, such as the attachments for the cord, then cylinders which need indicating, can be indicated in a few minutes, and the engineer can readily locate any trouble, provided he has studied the reading of the cards taken.

DESCRIPTION OF THE INDICATOR.

The principle of the indicator is to give the pressure prevailing inside the cylinder for each part of the stroke, telling exactly *what happens in the cylinder* at any time. To do this, it is con-

structed in certain respects like a steam cylinder. In a cylinder is placed a tight-fitting piston below which the pressure is admitted. Above the piston and secured to it, is placed a spring. Several springs of different tension are furnished, which can easily be exchanged. Their total compression, which is marked on them, should be a little higher than the pressure to be dealt with, but it should not be much higher in order to get the highest possible diagram, which will show the action the plainest.

To this cylinder is attached a drum, which is held taut against the starting stop by a coiled spring, so made that the same tension is on the cord, pulling the drum for one revolution of it, at the end of which another stop is provided. The cord, which must be good fishing line, so as not to stretch, runs over a little grooved pulley which is secured to the bottom of the drum, and the cord guided by a swivel roller. The piston is provided with a piston rod extending through the head, which is screwed on the cylinder to facilitate taking out the spring, and cleaning, and connected to a parallel motion carrying a pin on the one lever for marking on the paper which is put on the drum. It is best to use metallic coated paper and a composition pin, as this gives the sharpest lines.

To a screw at the bottom of the drum is attached the reducing pulley which carries the cord attached to the cross-head, and has, inside, a stiff spring to keep this cord taut. On the shaft of this large pulley small ones can be fastened, of which a number are furnished, and which are marked for the length of stroke they can be used.

PUTTING THE INDICATOR IN PLACE.

After the proper spring and pulley has been selected and adjusted to the indicator and the latter placed in position, the cord from the large pulley of the reducing pulley must be so adjusted that, if connected to the cross-head, it will be parallel to the piston rod in every direction, and, if held opposite the starting and stopping point of the attachment on the cross-head—not yet hooked in—the large pulley of the reducing pulley does not touch either of its stops. Now have somebody hold the end of the cord just opposite the attachment on the cross-head, at both ends of the stroke, and secure the cord of the drum to the small pulley of the reducing pulley so that the pin is evenly distant from the ends of the card holders of the drum at the two extreme positions.

Now put the paper on the drum and connect the cord to the cross-head attachment, and open the indicator cock connecting one side of the cylinder with the blow-off opening of the indicator cock to let out the water, in case of the steam cylinder, and the oil, in case of a compressor; in the latter case, you must be quick to open and shut the cock, and should hold a piece of waste before the opening, as otherwise you might get a disagreeable dose of ammonia in your face. Then turn the cock to the position to connect its cylinder with the steam cylinder, and press the pin gently against the paper, which must be drawn tight over the drum to prevent cutting by the pin. When one complete diagram has been made repeat the same operation of blowing off and taking the diagram on the other side, and, when finished, connect the inside of the indicator cylinder with the atmosphere to relieve it of its pressure, and again press the pin against the paper, which will then make a straight line, the so-called atmospheric line. Now disconnect the cord from the cross-head, and remove the paper from the drum, and mark on it date, pressures, number of revolutions and scale, also the name or number of the machine from which the card was taken. The card is then ready for inspection.

When providing indicator connections for each pump, engine and compressor, it is best to place a half-inch valve with nipple directly in the two outlets of the cylinder, and to connect them with a union and tee, the latter to correspond with the thread of its outlet to the male thread of the indicator cock. If it is not desired to make connection for all cylinders, only valves and nipples should be put in the cylinder openings, to prevent stopping the engine when taking cards. Then a connection with a three-way cock in the middle, provided with blow outlet, should be had, and such cock should have a stuffing box of sufficient length on one side to allow for adjustment in length of the connections. Pieces of pipe can then be cut to suit all lengths required.

CRITICISM OF INDICATOR CARDS.

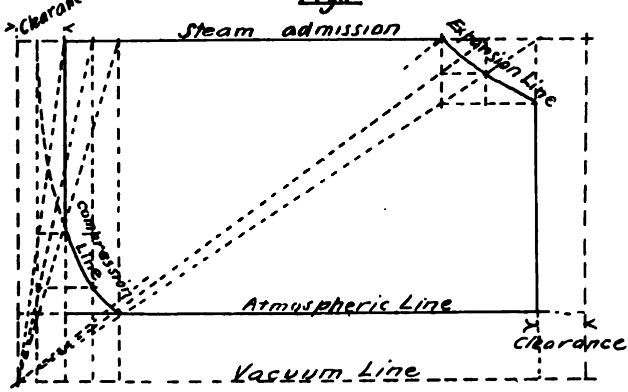
FOR STEAM ENGINES.

If it is desired only to examine the cards as to cut-off, cushion and admission of steam, no further preparation is necessary. If, *however, leakage of* piston and valves is to be examined, then *the expansion curve,* which is the isothermic curve for permanent

gases, must be laid in the diagram, which case will be considered later.

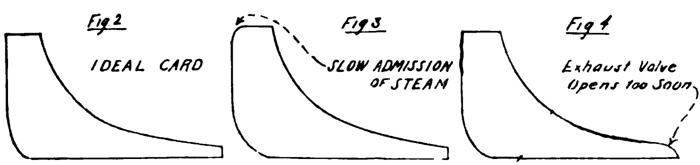
Fig. 2 shows a perfect card as it ought to be, but seldom is. Fig. 3 shows slow admission of the live steam, because the piston has traveled part of the stroke before sufficient steam opening

Fig. 1



was had to prevent throttling of the steam. In this case either the lead of the eccentric or the lead of the live steam valve must be increased.

For the purposes of this chapter it will hereafter be considered that the lead of the eccentric is correct, as advised in the chapter on steam engines for refrigerating machines, where the angle

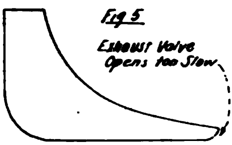


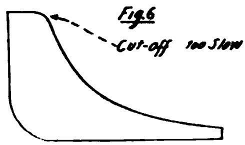
of lead for the eccentric is given as 25° for Corliss engines and 15° for slide-valve engines.

Fig. 4 shows that the exhaust valve opened too quickly, reducing the mean pressure and, consequently, the efficiency of the engine. The exhaust should not escape before the end of th

stroke, but the round corner proves that the exhaust valve opened too soon, allowing steam to escape which could have done work. In this case the lead of the exhaust valve must be reduced.

In Fig. 5 the exhaust valve opens too slowly, and the efficiency is reduced by compressing the exhaust or, better stated, throttling it. The pressure should drop in a straight line at the end of the stroke. In this case the lead of the exhaust valve must be increased.





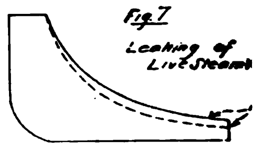
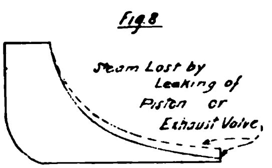
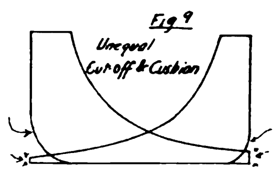


Fig. 6 shows that the cut-off is too slow, throttling the steam for a time instead of closing the live-steam valve quickly. This causes loss of efficiency because the steam is not used altogether expansively. Either the stuffing boxes of the valve stems are too tight, or the valve has no oil, or the vacuum under the dash-pot is not good and the latter should be examined, after the first two items are found not to apply. It may also be that the dash-pot has too much cushion.

Fig. 9 shows unequal cut-off and unequal cushion. The cut-off should be regulated by lengthening or shortening the rods.





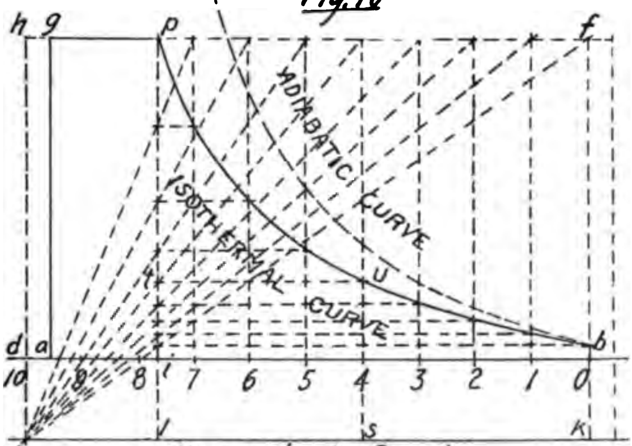
But it should first be ascertained which rod needs it. This can be done by raising the governor balls to the height the engineer knows they generally commence to act upon the cut-off. A piece of iron of the required height is generally kept for this purpose. It will thus be found which cut-off rod requires changing, which, of course, is the one not cutting off under this position of the balls. The piece of iron can be placed under the ring sliding on the governor stem.

The cushion must be equalized, and only experience and the knocking of the machine can advise as to which side to change. The side which has the knock, if there is one, surely is the one which needs more cushion, and the exhaust valve on this side must be made to close sooner. The exhaust line of the card should fall together with the atmospheric line, when no condenser is used, and the distance between both will give the amount of back pressure caused by obstruction in pipe or heater.

LEAKAGE OF PISTON AND VALVES.

To ascertain leakage of piston and valves we must construct the curve as the perfect card (Fig. 2) shows it. Fig. 10 shows

Fig. 10



Theoretical Card

this construction. Draw a line *ck* parallel to the atmospheric line *ab* in a distance of 15 pounds measured in the scale the indicator spring gives, ascertain the clearance of ports, exhaust and live, and for piston for one side, in cubic inches, and divide by the area in inches of the cylinder. This will give the clearance for one side, in inches of stroke of the cylinder. If the atmospheric line, which represents the length of the stroke in the diagram, measures *four inches*, and the stroke is twenty-four inches, then *the scale is one sixth* of an inch to one inch, and in this scal

the clearance must be added. In the sketch *ad* is this distance. Erect through this point and through the end of the expansion line *b* two verticals, starting at the vacuum line, until they meet a line which is the continuation of the steam admission line *gp* to both sides, in *h* and *f*; connect points *c* and *f* and draw a vertical through the cut-off point *p* to the vacuum line where this line (*pl*) and *cf* meet. Draw an horizontal line to the vertical *kf*, and this is the end of the expansion line. In the same way every other point of the curve can be found. For instance, to find the correct position of point *u*, which we assume to be one point of the curve made by the indicator, draw line *sr* through *u* and connect *r* with *c*. Where this line meets the cut-off line *pl*, draw an horizontal line *tu*, and where this line meets line *rs*, is the correct point *u*; and so on for all points of the curve.

ABRIDGED METHOD FOR FINDING LEAKAGE.

To save the engineer this rather tedious work, two diagrams are furnished, one for this curve, called the isothermic curve, and another one for the adiabatic curve of the permanent gases, which will be used later for the compressor cards (which see).

To use this diagram take the distance *bk* between the points of a compass and mark the height of same on the vertical erected at *o* in the diagram, draw line *xu*, and the lengths cut off by it from the other verticals are the ordinates for the diagram, which is used in the following manner:

Divide line *ck* of the sketch, or the atmospheric line with the clearance added to one side on your diagram, into ten parts, commencing on the side opposite to where you have added the clearance, and call the end of the expansion line *o*, and the divisions *1*, *2*, etc., up to ten. Erect verticals in these points, and make them just as long as the lines which you obtained by drawing line *xu* on diagram of isothermic curve. The end points of these verticals will give the right expansion curve. The same thing can be done to the other side of the diagram, but it should be remembered that the clearance should be added only once in each case and then on opposite sides.

After this curve has been laid into the diagram it will be noticed whether it corresponds with the line made by the indicator, as it should, if everything is as it should be. If not, for instance, as in Fig. 7, where the actual line lies above the theoretical line, then there must have been steam added after the

live steam valve had been closed by the cut-off, and, therefore, the live steam valve must leak, and should be looked after.

Fig. 8 shows the actual expansion line below the theoretical. This can have been caused only by steam leaking from the cylinder, or past the piston. Therefore, the piston rings must be out of order or the exhaust valve must leak.

EFFECTIVE MEAN PRESSURE.

Divide the atmospheric line into twenty parts, commencing to number the divisions with *o* at the end of the expansion line. Then measure with a strip of paper one after another of the verticals bearing odd numbers, commencing at the exhaust, not the atmospheric, line and stopping at the expansion curve. Add them all on the strip of paper. Measure the whole length of all the ordinates thus added, in the scale which is marked on the indicator spring, and divide the result by ten. This will give the average height of all the ordinates. In other words, it will give the height of a rectangle having as base line the atmospheric line and having equal cubic content as your diagram. Or, it gives the effective mean pressure of the diagram.

HORSE-POWER DEVELOPED BY THE ENGINE.

Having found the effective mean pressure, and knowing stroke diameter of cylinder and piston rod, it is easy to calculate the horse-power as indicated by the card.

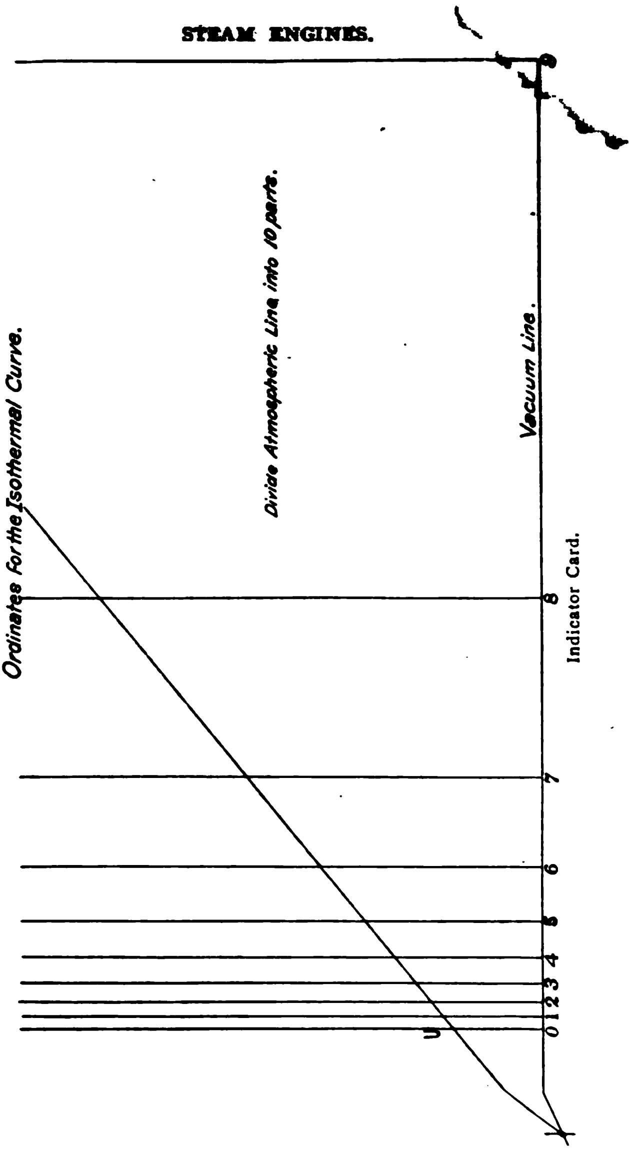
$$\text{The number of horse-power} = \frac{p \times (2 \times A - a) \times s \times r}{33000};$$

wherein p = effective mean pressure in pounds; A = area of steam cylinder in square inches; a = area of piston rod; s = stroke of the cylinder in feet; r = the number of revolutions per minute; *33000* the number of foot-pounds developed by one horse-power.

COMPRESSOR INDICATOR CARDS.

The action of the valve can be examined directly without further preparation, but for leakages the theoretical curve must be laid in the diagram taken, as explained in connection with steam diagrams.

Fig. 1 shows the isothermic and the adiabatic curves as transmitted from the diagram furnished for this purpose. The curve drawn *in the middle of* both represents the correct compression *curve for wet ammonia* which should be obtained in the actual



Indicator Card.

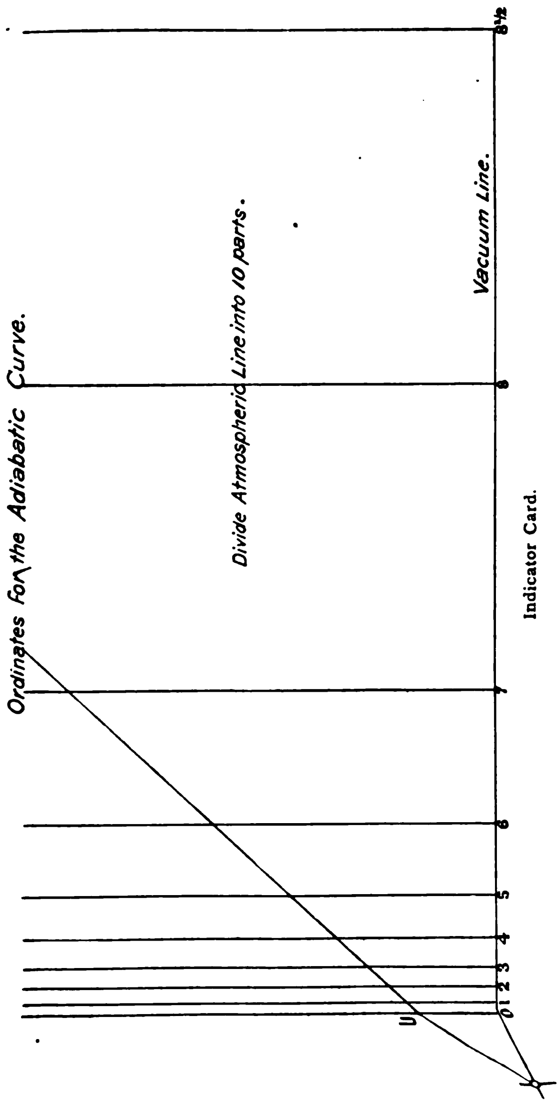
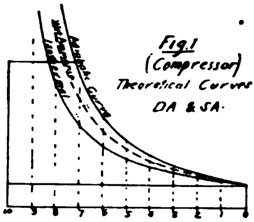
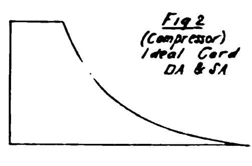

Ordinates For the Adiabatic Curve.
Divide Atmospheric Line into 10 parts.
Vacuum Line.
Indicator Card.
U
0 1 2 3 4 5 6 7 8 8½

diagram if the compressor was properly handled. This curve is also correct for the oil circulating compressor, for all practical purposes. To construct the curve for the wet ammonia compression with absolute accuracy, is rather tedious, as the curve of the saturated ammonia must first be drawn, and then the addition be made of the increase of pressure by the evaporation of the liquid injected with the gas, and to do this correctly, the tempera-



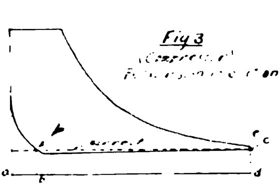


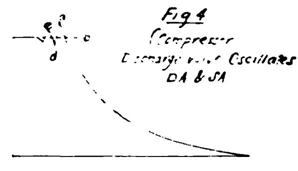
ture of the discharge gas must be ascertained, since in practice sufficient liquid can not be admitted, as otherwise the control of the compressor would be lost as explained in connection with refrigeration.

Fig. 2 represents the card as it should be.

Fig. 3 shows the effect of re-expansion, caused either by too much clearance or by the discharge valve when not seating promptly.

In order to ascertain how much the capacity of the compressor is reduced by it, erect a vertical line *dc* in *d*. Where this line is

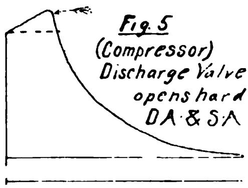


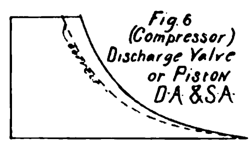


tangent to the diagram, which is at *c*, draw an horizontal line until it meets the re-expansion line. The distance *ab* represents the part of the stroke during which no new gas was admitted, but only gas which had been compressed previously had expanded. The *height of the vertical cd* represents the pressure of the gas which *filled the compressor* at the end of the suction period, and the

loss of capacity is proportional to the length of the distances *ad* to *ab*; *ad* representing the stroke of the compressor.

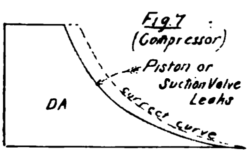
Fig. 4 shows the influence of a discharge valve which is either too heavy, or has too much seat, or too much cushion above. The pressure must first be raised to *c* in order to lift the valve,

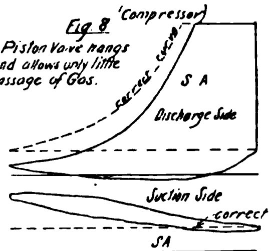




but owing to the large opening suddenly offered to the gas, the pressure falls again below the pressure prevailing in the condenser which forces the valve to its seat. The pressure now rises again, but not so high as before, opens the valve, when the pressure is again reduced below the condenser pressure, forcing the discharge valve a second time to seat. Finally the valve opens for good, and stays open to the end of the stroke.

Fig. 5 shows the effect of the discharge valve hanging. It throttles the gas, making it necessary for the pressure below





the valve to rise much higher than necessary, and additional power is required to perform this unnecessary work.

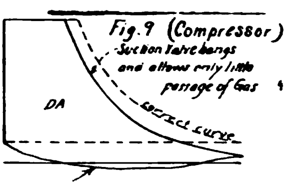
Fig. 6. Draw the correct curve in it, and the diagram shows that the discharge valve must leak, provided the gas was not superheated during compression, i. e., the gas has not carried sufficient liquid into the compressor to absorb the heat of compression, and the volume has been increased by the heat, not by *leakage*.

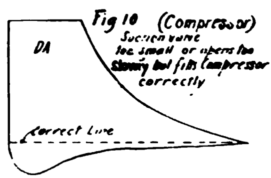
Fig. 7, after the correct curve has been drawn in it, shows that there is a leakage either in piston or suction valve, in the case of a double action (*DA*) compressor. Gas has escaped during compression, and loss in capacity is the result.

Fig. 8 shows the effect of the piston valve hanging, not being either quite open or shut, and gas passing through it in insufficient quantities to fill the upper part of the compressor properly, and partly compressing the gas in the lower part of the compressor, as shown by the diagram taken from this part of the compressor. This refers only to single acting (*SA*) machines, as *DA* machines have no piston valve.

Fig. 9 shows the effect of a suction valve hanging in a *DA* compressor, which has the same effect as in the upper part of the *SA* compressor shown in Fig. 8.

Fig. 10 shows that the suction valve is either too small or opens too slowly, not allowing free passage for the gas in a *DA*





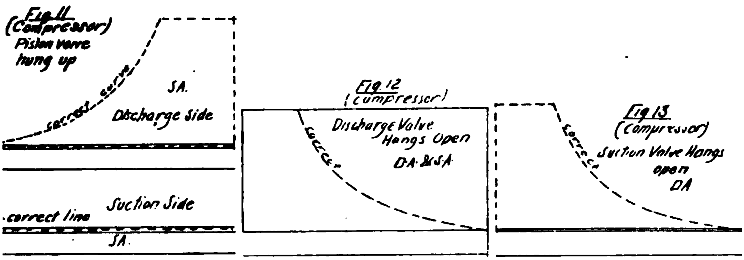
compressor. This does not influence the capacity of the machine if only the admission line reaches the suction pressure before compression commences, as indicated by the gauge. It is very important to compare the gauge pressures with the indicator pressures, as they will often tell a story of too small suction and discharge pipes or openings.

When reading the gauges, always take the lowest point of the oscillation the hand makes for the proper reading, as this gives the pressure prevailing in the pipes, while the upper point of the oscillation is only reached by the sudden closing of the valves causing a reaction upon the gauge, that is, a ram is produced.

Fig. 11 shows that the piston valve of a *SA* compressor is held up, the gas passing freely through the piston both ways, making but a slight compression of a few pounds above and below. Of course, both diagrams must show alike, the one taken from the lower part and the one taken from the upper part of the compressor.

Fig. 12 shows the discharge valve hung up, giving free passage to the gas. The compressor must, therefore, be filled with gas at condensing pressure.

Fig. 13 shows the suction valve of a *DA* compressor hung up, allowing free passage for the gas in and out, and no gas is discharged, as the discharge valve cannot open.



The effective mean pressure and horse-power needed for compressing the gas can now be found in the same way as the horse-power of a steam engine. It must only be remembered that the formula there given is for one double-acting cylinder, and that the result for one single-acting compressor will be only about one-half the amount. The correct formula here is

$$HP = \frac{p \times s \times r \times A}{33000}.$$

It is interesting to take the indication of the engine connected to the compressor under the same conditions—better at the same time—and, by subtracting the amounts obtained for both, to ascertain the friction of the machine. This friction should be about 25 per cent of the horse-power required for the compressor for *DA* compressors, and 33 per cent for *SA* compressors.

It can now also be determined what the difference is in power required by a dry and a wet compressor, by freezing back correctly at one time, and, for the other diagram, keeping away the frost from the compressor.

STEAM CONDENSERS.

If it is desired only to obtain distilled water, and a cheap apparatus is wanted, which is at the same time a steam filter and steam washer, also a feed-water heater, then the Holms filter can be recommended where the cooling water does not scale much.

The Open Air Holms Steam Condenser consists of two galvanized iron cylinders, one placed in the other. The outer cylinder and the inner cylinder are secured tightly to the bottom, and there is no communication between them below. The outer cylinder is provided with a conical top, and a safety valve placed on the highest point of this cover. The inner cylinder reaches almost to the top of the outer cylinder in order to allow free passage to the steam from the inner cylinder into the annular space formed by the two cylinders. Near the top of the outer cylinder, forming another annular space, is placed another receptacle reaching beyond the conical top, for the reception of the feed water, which is heated by the steam passing the upper part of the outer cylinder and striking against the conical top.

Just below this feed-water receptacle is placed a trough for distributing the cooling water over the outside of the outer cylinder, which stands vertical in order to allow the water to flow down its exterior surface. The water is fed to this trough by a single coil of pipe placed in the trough and perforated with small holes. The steam enters the condenser near the bottom, passing through the annular space into the inner cylinder and ending in a funnel pointing downward. The funnel is kept with its orifice about one inch under water which will collect, and the height of which is regulated by a pipe goose-neck passing through the annular space to the outside, and a drain valve is provided to drain the inner cylinder.

Above this exhaust funnel is placed a grating covered with a fine wire screen; above this, coke is placed nearly to the top of the inner cylinder, and again a grating and wire screen to hold the coke in place. The larger pieces of coke are placed below the smaller ones on top. The annular space is provided with an outlet for condensed water on the bottom, and the safety valve on top of the conical top is counterweighted so that it will blow off at two pounds' pressure as the vessel is not built either for pressure or a vacuum. The exhaust steam is discharged from the funnel into the water, and washed, and so freed partly from oil. It then passes through the coke, which retains the rest of the oil, and into the annular space between the two cylinders, where the steam *is condensed* and runs out of the bottom outlet of the annular space.

The feed water is fed to the bottom of the receptacle provided for it, and allowed to overflow on top.

The coke must be renewed at least every season, and Connelsville coke is the best for this purpose. The combination is a good one, as it furnishes a cheap feed-water heater, and saves the insulation for feed-water heater and steam filter which otherwise would have to be provided. The air helps the condensing materially, the water running in a thin film over the outer shell, and being partly evaporated. It acts as in a cooling tower, cooling the water itself.

The water collected in the inner cylinder from condensation of the steam is of considerable amount, and this is a disadvantage, as this water is greasy and cannot be used. Furthermore, if the water forms scale, the shell requires frequent cleaning, and leaks will soon appear. But the apparatus is so cheap that one can afford to buy a new one every year.

Holms Submerged Condenser.—To the above is added a third cylinder encasing the two first ones, and in the annular space between the second and third one the cooling water circulates, being thus not exposed to the influence of the air. Ordinarily it will not scale enough to make the removal of the outer shell necessary for cleaning. The water enters at the bottom and overflows at the top.

CONDENSERS WHICH CAN BE USED FOR PRODUCING DISTILLED WATER AND A VACUUM AT THE SAME TIME.

Open Air Pipe Condensers.—These are made of the size pipe to fit the opening of the exhaust, and erected in stacks, the steam entering at the top and the condensed water leaving at the bottom. The cooling water is showered over the cooler by means of a gutter.

They are efficient, and use the water to advantage, but not so good as the sectional ones.

Sectional Open Air Pipe Condensers.—These condensers are made of two-inch pipe in three sections, the upper one consisting of three pipes, the next one of five, and the lowest of seven. The pipes are slightly inclined so as to drain toward the outlet which is at the bottom. The three outlets and inlets are connected each to one vertical header, and this header again connects the inlet headers on top and the outlet headers at the bottom

to the main pipes. The inlet headers are connected on top to drain any oil which is carried with the steam from the steam cylinder, and form excellent traps. Drain cocks are provided for each inlet header. The drains should all be allowed to empty into funnels, so as to allow observation of what is running out.

One condenser, ten feet long, is sufficient to condense five tons of water per day. The condensed water leaves the condenser at about 170°, while the cooling water leaves at 160°, and can well be used for feed-water, if clean. Submerged pipe coolers are generally laid horizontal, or, better, a little on the incline in order to drain well. But owing to the slow motion of the water running over them, much more water and much more surface is required to accomplish the same results as with open air coolers.

Another form of submerged pipe cooler is the usual cylindrical form, like a heater, either vertical or horizontal. The cylinder is filled with five-eighth or three-quarter-inch brass or composition tubes, fitted between two pipe heads placed inside the outer cylinder, and forming a passage for the water at both ends between pipe-head and cylinder-head. An horizontal partition is often put in on the opposite side to the inlet, separating the upper half of the tubes from the lower ones, and thus sending the water twice through the condenser, using it to better advantage. The steam enters the shell at the top, and the condensed water leaves at the bottom.

If used for compound condensing engines provide two square feet of surface per horse-power per hour. In this case, where the condensation must be done in a vacuum, an air pump must be provided to expel the air and the condensed water. Sometimes a dry air pump is used, and the water expelled by another pump. There are combinations furnished, where all pumps required are directly connected with the surface condenser. The vacuum pump must be of such size as to maintain a vacuum of twenty-six inches.

The amount of injection water required depends on the temperature of the cooling water and the vacuum required. It is generally from twenty-five to thirty times the weight of steam condensed.

Injection Condenser.—Here the steam is brought into direct contact with the water in a vessel placed on top of the air pump.

Here, of course, the distilled water is lost, since it is mixed with the cooling water.

These condensers are cheap, and yet effective, and if the distilled water is of no value, this condenser will be preferable to a surface condenser. If the cooling water is good enough for boiler feeding, the water discharged from this vacuum pump is available, and is about as hot as the condensed steam from the surface condenser.

The Syphon Condenser.—This condenser requires no vacuum pump, but does not furnish distilled water either. It is cheaper and just as efficient as the surface condenser, but cannot handle varying loads so well as the surface condenser.

It is based on the principle of a syphon. When water is allowed to fall thirty-two feet in a pipe, which it fills, it will be able to create a vacuum of twenty-nine inches in a vessel filled with air, and about twenty-six inches when the vessel is filled with steam, in this case the steam cylinder. The exhaust steam is led thirty-two feet high into a pipe through which water flows which creates this vacuum by falling thirty-two feet in the pipe, and at the same time condenses the steam. This water can again be used for feed-water. The amount of cooling water is the same as for an injection condenser, i. e., about twenty to twenty-five times the weight of the steam to be condensed. The height of the two pipes may be an objection in some cases.

All condensers should be provided with safety devices in order to prevent backing of the water into the cylinder, and a by-pass pipe should be provided which, by means of a pressure regulating valve, leads off the exhaust automatically. A valve should be provided, so that the condenser can be shut off while the engine is exhausting into the atmosphere, and the condenser can be repaired, if necessary, without shutting down the engine.

In calculating pressures required by pumps to discharge given quantities of water at given levels, the following tables may be used in connection with formulas given in the chapter Mechanics (head Hydraulics) for computing discharge, etc., by converting the pressure into head.

Absolute Pressure per Sq. Inch.	Absolute Pressure in Mercury.	Temperature.	Total Heat from Water at 32°.	Volume of 1 Lb.	Density, or Weight of one Cubic Foot.	Absolute Pressure per Sq. Inch.	Absolute Pressure in Mercury.	Temperature.	Total Heat from Water at 32°.	Volume of 1 Lb.	Density, or Weight of one Cubic Foot.
Lbs.	Ins.	°	°	Cub. ft.	Lb.	Lbs.	Ins.	°	°	Cub. ft.	Lb.
1	2.04	102.1	1112.5	330.36	.003	58	118.08	290.4	1170	7.24	.138
2	4.07	126.3	1119.7	172.08	.0058	59	120.12	291.6	1170.4	7.12	.1403
3	6.11	141.6	1124.6	117.52	.0085	60	122.16	292.7	1170.7	7.01	.1425
4	8.14	153.1	1128.1	89.62	.0112	61	124.19	293.8	1171.1	6.9	.1447
5	10.18	162.3	1130.9	72.66	.0138	62	126.23	294.8	1171.4	6.81	.1469
6	12.22	170.2	1133.3	61.21	.0163	63	128.26	295.9	1171.7	6.7	.1493
7	14.25	176.9	1135.3	52.94	.0189	64	130.3	296.9	1172	6.6	.1516
8	16.29	182.9	1137.2	46.69	.0214	65	132.34	298	1172.3	6.49	.1538
9	18.32	188.3	1138.8	41.79	.0239	66	134.37	299	1172.6	6.41	.156
10	20.36	193.3	1140.3	37.84	.0264	67	136.4	300	1172.9	6.32	.1583
11	22.39	197.8	1141.7	34.63	.0289	68	138.44	300.9	1173.2	6.23	.1605
12	24.43	202	1143	31.88	.0314	69	140.48	301.9	1173.5	6.15	.1627
13	[illegible]	205.9	1144.2	29.57	.0338	70	142.52	302.9	1173.8	6.07	.1648
14	28.51	209.6	1145.3	27.61	.0362	71	144.55	303.9	1174.1	5.99	.167
14.7	29.92	212	1146.1	26.36	.03802	72	146.59	304.8	1174.3	5.91	.1692
15	30.54	213.1	1146.4	25.85	.0387	73	148.62	305.7	1174.6	5.83	.1714
16	32.57	216.3	1147.4	24.32	.0411	74	150.66	306.6	1174.9	5.76	.1736
17	34.61	219.6	1148.3	22.96	.0435	75	152.69	307.5	1175.2	5.68	.1759
18	36.65	222.4	1149.2	21.73	.0459	76	154.73	308.4	1175.4	5.61	.1782
19	38.68	225.3	1150.1	20.7	.0483	77	156.77	309.3	1175.7	5.54	.1804
20	40.72	228	1150.9	19.72	.0507	78	158.8	310.2	1176	5.48	.1826
21	42.75	230.6	1151.7	18.84	.0531	79	160.84	311.1	1176.3	5.41	.1848
22	44.79	233.1	1152.5	18.03	.0555	80	162.87	312	1176.5	5.35	.1869
23	46.83	235.5	1153.2	17.26	.058	81	164.91	312.8	1176.8	5.29	.1891
24	48.86	237.8	1153.9	16.64	.0601	82	166.95	313.6	1177.1	5.23	.1913
25	50.9	240.1	1154.6	15.99	.0625	83	168.98	314.5	1177.4	5.17	.1935
25	52.93	242.3	1155.3	15.38	.065	84	171.02	315.3	1177.6	5.11	.1957
27	54.97	244.4	1155.8	14.86	.0673	85	173.05	316.1	1177.9	5.05	.198
28	57.01	246.4	1156.4	14.37	.0696	86	175.09	316.9	1178.1	5	.2002
29	59.04	248.4	1157.1	13.9	.0719	87	177.13	317.8	1178.4	4.94	.2024
30	61.05	[illegible]	1157.8	13.46	.0743	88	179.16	318.6	1178.6	4.89	.2044
31	63.11	[illegible]	[illegible]	13.05	.0766	89	181.2	319.4	1178.9	4.84	.2067
32	65.15	[illegible]	1158.9	12.67	.0789	90	183.23	320.2	1179.1	4.79	.2089
33	[illegible]	[illegible]	[illegible]	12.31	.0812	91	185.27	321	1179.3	4.74	.2111
34	[illegible]	[illegible]	1160	[illegible]	.0835	92	187.31	321.7	1179.5	4.69	.2133
35	[illegible]	[illegible]	[illegible]	11.05	.0858	93	189.34	322.5	1179.8	4.64	.2155
36	[illegible]	[illegible]	1161	11.24	.0881	94	191.38	323.3	1180	4.6	.2176
37	75.33	[illegible]	[illegible]	11.04	.0905	95	193.41	324.1	1180.3	4.55	.2198
38	[illegible]	[illegible]	1162	10.75	.0929	96	195.45	324.8	[illegible]	4.51	.2219
39	[illegible]	[illegible]	[illegible]	10.51	.0952	97	197.49	325.6	[illegible]	[illegible]	.2241
40	[illegible]	[illegible]	[illegible]	10.27	.0974	98	199.52	326.3	1181	4.42	.2263
41	[illegible]	[illegible]	[illegible]	10.03	.0996	99	201.56	327.1	1181.2	4.37	.2285
42	[illegible]	[illegible]	1163.8	9.81	.102	100	203.59	[illegible]	1181.4	4.33	.2307
43	[illegible]	[illegible]	1164.2	9.59	.1042	101	[illegible]	328.5	[illegible]	[illegible]	.2329
44	[illegible]	273	[illegible]	9.39	.1065	102	[illegible]	[illegible]	[illegible]	4.25	.2351
45	[illegible]	274.4	1165.1	9.18	[illegible]	103	209.7	[illegible]	1182	4.21	.2373
46	[illegible]	[illegible]	1165.5	9	.1111	104	211.74	[illegible]	[illegible]	[illegible]	.2393
47	[illegible]	277.1	1165.9	8.82	.1133	105	[illegible]	331.3	[illegible]	4.14	.2414
48	[illegible]	[illegible]	1166.3	8.65	[illegible]	106	[illegible]	[illegible]	[illegible]	4.11	.2435
49	[illegible]	[illegible]	1166.7	8.48	[illegible]	107	217.84	[illegible]	[illegible]	[illegible]	.2456
50	[illegible]	281	1167.1	8.31	[illegible]	108	[illegible]	333.3	1183	[illegible]	.2477
51	[illegible]	[illegible]	1167.5	8.17	[illegible]	109	[illegible]	334	[illegible]	[illegible]	[illegible]
52	[illegible]	283.5	1167.9	8.04	.1246	110	[illegible]	[illegible]	[illegible]	[illegible]	.2521
53	[illegible]	284.7	1168.3	7.88	[illegible]	111	[illegible]	335.3	[illegible]	[illegible]	.2543
54	[illegible]	[illegible]	1168.6	7.74	.1291	112	[illegible]	335	[illegible]	[illegible]	[illegible]
55	[illegible]	287.1	1169	7.61	.1314	113	[illegible]	336.7	[illegible]	[illegible]	[illegible]
56	114.01	[illegible]	1169.3	7.48	.1336	114	232.1	337.4	[illegible]	[illegible]	[illegible]
57	116.05	289.3	1169.7	7.36	.1364	115	234.13	[illegible]	[illegible]	[illegible]	[illegible]

See also page 185

Absolute Pressure per Sq. Inch.	Absolute Pressure in Mercury.	Temperature.	Total Heat from Water at 32°.	Volume of 1 Lb.	Density, or Weight of one Cube Foot.	Absolute Pressure per Sq. Inch.	Absolute Pressure in Mercury.	Temperature.	Total Heat from Water at 32°.	Volume of 1 Lb.	Density, or Weight of one Cube Foot.
Lbs.	Ins.	°	°	Cub. ft.	Lb.	Lbs.	Ins.	°	°	Cub. ft.	Lbs.
116	236.17	338.6	1184.7	3.77	.2649	149	303.35	357.8	1190.5	2.98	.3357
117	238.2	339.3	1184.9	3.74	.2652	150	305.39	358.3	1190.7	2.96	.3377
118	240.24	339.9	1185.1	3.71	.2674	155	315.57	361	1191.5	2.87	.3484
119	242.28	340.5	1185.3	3.68	.2696	160	325.75	363.4	1192.2	2.79	.359
120	244.31	341.1	1185.4	3.65	.2718	165	335.93	366	1192.9	2.71	.3695
121	246.35	341.8	1185.6	3.62	.2759	170	346.11	368.2	1193.7	2.63	.3798
122	248.38	342.4	1185.8	3.59	.278	175	356.29	370.8	1194.4	2.56	.3899
123	250.42	343	1186	3.56	.2801	180	366.47	372.9	1195.1	2.49	.4009
124	252.45	343.6	1186.2	3.54	.2822	185	376.65	375.3	1195.8	2.43	.4117
125	254.49	344.2	1186.4	3.51	.2845	190	386.83	377.5	1196.5	2.37	.4222
126	256.53	344.8	1186.6	3.49	.2867	195	397.01	379.7	1197.2	2.31	.4327
127	258.56	345.	1186.8	3.46	.2889	200	407.19	381.7	1197.8	2.26	.4431
128	260.6	346	1186.9	3.44	.2911	210	427.54	386	1199.1	2.16	.4634
129	262.64	346.	1187.1	3.41	.2933	220	447.9	389.9	1200.3	2.06	.4842
130	264.67	347.	1187.3	3.38	.2955	230	468.26	393.8	1201.5	1.98	.5052
131	266.71	347.8	1187.5	3.35	.2977	240	488.62	397.5	1202.6	1.9	.5248
132	268.74	348.3	1187.6	3.33	.2999	250	508.98	401.1	1203.7	1.83	.5464
133	270.78	348.9	1187.8	3.31	.302	260	529.34	404.5	1204.8	1.76	.5669
134	272.81	349.5	1188	3.29	.304	270	549.7	407.9	1205.8	1.7	.5868
135	274.85	350.	1188.2	3.27	.306	280	570.06	411.2	1206.8	1.64	.6081
136	276.89	350.6	1188.3	3.25	.308	290	590.42	414.4	1207.8	1.59	.6278
137	278.92	351.2	1188.5	3.22	.3101	300	610.78	417.5	1208.7	1.54	.6486
138	280.96	351.8	1188.7	3.2	.3121	350	712.57	430.1	1212.6	1.33	.7498
139	282.99	352.	1188.9	3.18	.3142	400	814.37	444.9	1217.1	1.18	.8502
140	285.03	352.	1189	3.16	.3162	450	916.17	456.7	1220.7	1.05	.9499
141	287.07	353.	1189.2	3.14	.3184	500	1018	467.5	1224	.95	1.049
142	289.1	354	1189.4	3.12	.3206	550	1119.8	477.5	1227	.87	1.148
143	291.14	354.	1189.6	3.1	.3228	600	1221.6	487	1229.9	.8	1.245
144	293.17	355	1189.7	3.08	.325	650	1323.4	495.6	1232.5	.74	1.342
145	295.21	355.6	1189.9	3.06	.3273	700	1425.8	504.1	1235.1	.69	1.4395
146	297.25	356.1	1190	3.04	.3294	800	1628.7	519.5	1239.8	.61	1.6322
147	299.28	356.7	1190.2	3.02	.3315	900	1832.3	533.6	1244.2	.55	1.8235
148	301.32	357.2	1190.3	3.	.3336	1000	2035.9	546.5	1248.1	.5	2.014

Temperature.	Absolute Pressure Mercury.	Absolute Pressure Per Sq. Inch.	Weight of 100 Cub. Feet.	Volume of 1 Lb.	Temperature.	Absolute Pressure Mercury.	Absolute Pressure Per Sq. Inch.	Weight of 100 Cub. Feet.	Volume of 1 Lb.
°	Ins.	Lbs.	Lb.	Cub. Feet.	°	Ins.	Lbs.	Lbs.	Cub. Feet.
32	.181	.089	.031	3226	125	3.933	1.932	.554	180.5
35	.204	.1	.034	2941	130	4.509	2.215	.63	158.7
40	.248	.122	.041	2439	135	5.174	2.542	.714	140.1
45	.299	.147	.049	2041	140	5.86	2.879	.806	124.1
50	.362	.178	.059	1695	145	6.662	3.273	.909	110
55	.426	.214	.07	1429	150	7.548	3.708	1.022	97.8
60	.517	.254	.082	1220	155	8.535	4.193	1.145	87.3
65	.619	.304	.097	1031	160	9.63	4.731	1.333	75
70	.733	.36	.114	877.2	165	10.843	5.327	1.432	69.8
75	.869	.427	.134	746.3	170	12.183	5.985	1.602	62.4
80	1.024	.503	.156	641	175	13.654	6.708	1.774	56.4
85	1.205	.592	.182	549.5	180	15.291	7.511	1.97	50.8
90	1.41	.693	.212	471.7	185	17.041	8.375	2.181	45.9
95	1.647	.809	.245	408.2	190	19.001	9.335	2.411	41.5
100	1.917	.942	.283	353.4	195	21.139	10.385	2.662	37.6
105	2.229	1.095	.325	307.7	200	23.461	11.526	2.933	34.1
110	2.579	1.267	.373	268.1	205	25.994	12.77	3.225	31
115	2.976	1.462	.426	234.7	210	28.753	14.127	3.543	28.2
120	3.43	1.685	.488	204.9	212	29.922	14.7	3.683	27.2

REFRIGERATION.

Refrigeration is the process of abstracting heat from, or cooling, a substance.

Where water or air is at hand at a lower temperature than it is desired to obtain in the body to be cooled, such water or air can be used to do this cooling directly without a machine.

Ice can be used directly if temperatures of 32° and above are desired, and a mixture of salt and ice or other freezing mixtures can be used to obtain lower temperatures than 32°, and without a machine.

ICE AND FREEZING MIXTURES.

One pound of calcium chloride, when mixed with ice or snow (see table), will give a solution, the lowest possible temperature of which will be found opposite the respective quantity of ice:

MIXTURE MADE AT 32°.

Pounds of Snow.	Lowest Temperature.	Pounds of Snow.	Lowest Temperature.
0.35	+32°	0.55	−20°
0.39	+24°	0.57	−28°
0.43	+13°	0.61	−38°
0.45	+ 7°	0.63	−42°
0.48	0°	0.64	−50°
0.49	− 3°	0.66	−57°
0.51	− 9°	0.70	−67°

But since all freezing mixtures and even ice are far too expensive to be used for practical purposes, it is safe to say that whenever water or air cannot be used directly a machine must be employed.

Practical temperatures which can be obtained by using ice for *air-cooling are 40° to 45°*, and the air in the rooms cooled by it *is very moist.*

The lowest temperature which a freezing mixture can attain is the freezing point of the resulting solution:

Mixture.	Proportion in Weight.	Temperature Drops From	Temperature Drops To
Sodium chloride	1	+32°	− 0°
Snow or pounded ice	1		
Ammonia nitrate	1	+50°	+ 3°
Water	1		
Sodium phosphate	9	+50°	+16°
Nitric acid dilute	4		
Sodium sulphate	6	+50°	− 9°
Sal-ammoniac	4		
Potassium nitrate	2		
Nitric acid dilute	4		
Sodium chloride	1	+50°	0°
Snow or pounded ice	3		
Potassium nitrate	1	+46°	−11°
Sal-ammoniac	1		
Water	1		
Nitric acid dilute	1	+ 7°	−31°
Snow or pounded ice	1		
Potash	4	+32°	−35°
Snow or pounded ice	3		
Sodium phosphate	9	+55°	+21°
Sal-ammoniac	6		
Nitric acid dilute	4		
Sodium sulphate	6	+50°	−13°
Ammonium nitrate	5		
Nitric acid dilute	4		
Sal-ammoniac	5	+50°	+10°
Potassium Nitrate	5		
Water	6		
Sodium carbonate	1	+50°	+ 7°
Ammonium nitrate	1		
Water	11		
Sodium sulphate	3	+50°	− 2°
Nitric acid dilute	2		
Sodium sulphate	8	+50°	+ 5°
Potassium nitrate	5		
Sal-ammoniac	5		
Water	6		
Sodium sulphate	8	+50°	0°
Muriatic acid	5		
Sodium sulphate	15	+50°	+ 3°
Sulphuric acid dilute	4		
Sulphuric acid dilute	1	− 2°	−40°
Nitric acid diluted	1		
Snow or pounded ice	2		
Sulphuric acid dilute	1	+23°	−42°
Snow or pounded ice	1		
Calcium chloride	3	+32°	−27°
Snow or pounded ice	2		
Calcium chloride	2	+32°	−44°
Snow or pounded ice	1		

Owing to unsatisfactory temperature, the excessive moisture in the rooms, and the expensive handling of the ice, little use is made of ice for cooling purposes at the present time in manufacturing plants.

However, if an emergency arises, and no machine is on hand, or the machine at disposal is too small, then it might pay to mix salt and ice, or calcium chloride and ice, and use this solution for cooling purposes. For instance, five pounds of snow or pounded ice mixed with one pound of calcium chloride will furnish a solution having a lowest temperature of 25°, which is usually sufficient for all practical purposes. One pound common salt, if mixed with three pounds of snow, or pounded ice, will give a solution, the lowest temperature of which is 6°.

The chemical, in this instance, does not help cooling; it only allows the mixture to attain such a low temperature because the mixtures it produces have such low freezing points as 25° and 6°. It must be understood that this temperature can only be obtained when the mixture does no cooling work, or ice and chemicals are constantly added so as to have always undissolved parts of both in the solution.

REFRIGERATING MACHINES.

There are, first, two divisions to be made according to the nature of the medium employed:

1. Permanent gases, which will not liquify under ordinary conditions, as, for instance, air.
2. Liquifiable gases as ammonia, carbon dioxide, sulphur dioxide, sulphuric ether, etc.

The first class employing permanent gases—air being the only one practically used—must again be divided into three classes, according to the manner of handling the medium, viz.:

1. Vacuum machines;
2. Air compression machines;
3. Dense air compression machines.

VACUUM MACHINE.

This machine is based upon the fact that water will evaporate at a temperature below 32°, the freezing point of water, when such evaporation takes place under a pressure of below 0.181" of mercury, which is almost a perfect vacuum. To maintain such vacuum continually, requires a very finely built machine, and the

water vapor which is produced during the process must be absorbed by sulphuric acid, as otherwise it would be almost impossible to maintain the required vacuum for any length of time.

The machine consists of a freezing chamber connected to a vacuum pump, from which the mixture of gases—air and water vapor—is passed off through a vessel containing trays filled with strong sulphuric acid before entering the vacuum pump, so that the pump really has to handle only air, which is discharged as useless. The sulphuric acid must be taken out from time to time, and strengthened again by boiling in lead vessels.

AIR COMPRESSION MACHINES.

This machine is based upon the fact that when air is compressed, heat is developed, and when air is allowed to expand, heat is absorbed. But this is true only when the expansion takes place in a cylinder, the piston of which is pushed by the expanding gas. Air under heavy pressure. leaving a large vessel through a small opening, will not do any cooling, except a trifle at the orifice, and this only because it performs some work there which, however, is minute in comparison with the work it could perform if expanding behind a piston. The work performed in this instance is the friction of the out-rushing air on the sides of the opening, and the work required to push the outer air aside. At higher pressures, Prof. Linde found that some cooling effect is exercised by a reduction of pressure, the temperature being reduced about ½° F. per atmosphere (15 pounds) pressure.

After the air has been compressed to the desired point, having been taken into the compressor from the atmosphere, it is sent into a cooler over which water is showered, and cooled as low as the water will do it, then it is allowed to flow into a second cylinder, the so-called expansion cylinder. In this cylinder the air expands, driving at the same time the piston through the cylinder. At the end of the stroke. the air is considerably cooler, having been allowed to expand. and is now allowed to enter the rooms to be cooled. The compression and the expansion cylinders are coupled to the same shaft, and the work performed in the expansion cylinder by the expanding gas materially assists the compressor.

It is evident that the heat which was produced by compressing the gas, and then removed by the water in the cooler, must be *an equal amount as the* heat transformed into work during the

expansion of the air, or, in other words, if we ascertain how many heat-units the water has received, by multiplying the number of pounds of water with the difference of temperatures of the water when entering and when leaving the cooler, we have the amount of cooling work which the expanded air can do.

DENSE AIR COMPRESSION MACHINES.

The principle of this machine is, in the main, the same as that of the one just described. The only difference is the fact that the dense air machine admits the air to the compressor at a higher pressure than atmospheric, generally at about 60 pounds. This is done in order to reduce the size of the compressor, since air of 60 pounds weighs 2½ times as much as air of 15 pounds' pressure. Consequently the area of the compression cylinder can be reduced by a corresponding amount.

The construction of the machine is the same as that of the machine taking in air at atmospheric pressure, except that the expanded air is sent into coils of pipes instead of into the room directly. This is done in order to be able to maintain a pressure of 60 pounds.

LIQUEFIABLE GAS MACHINES.

The machines using a liquifiable gas can be divided again into two principal classes:

1. The compression machines.
2. The absorption machines.

COMPRESSION MACHINES.

The principle of these machines is based on the ability of certain gases to become liquid by cooling with water, or air, of a temperature at our disposal when compressed to pressures practically obtainable, and on the other hand their ability to evaporate at temperatures required in the cooling coils.

The process is as follows: The gas, leaving the cooling coils, enters the compressor, and is therein compressed to such a point that the water, running over the condensers, into which the gas is discharged by the compressor, can liquify it. The liquid so formed is sent to the cooling coils, and has to pass an expansion cock on the way. The object of this cock is to reduce the pressure of the liquid to the pressure prevailing in the coils.

It is evident that a liquid having, for instance, a temperature of 95°, *corresponding to* a condensing pressure of 156 pounds, can-

not evaporate in coils surrounded by brine, say of 18°, the temperature of the gas in the coils being 14°. Therefore, the liquid must first be brought to a temperature of 14°. This is accomplished by the expansion cock. Part of the liquid evaporates while passing the cock and cools the remainder to 14°. There is thus obtained a mixture of about 12 per cent in weight of gas, and about 88 per cent of liquid, the latter only doing useful work. The cooling effect of the 12 per cent utilized for cooling the remaining liquid is absolutely lost. After the liquid has all been evaporated it flows back to the compressor and goes through the same routine as before.

These machines are built horizontal and vertical, meaning, by this, that the compressors are either horizontal or vertical. They are further built with two or one compressors, and finally, as double-acting and single-acting compressors, necessitating different arrangement of parts.

Compression is performed in one of three different ways:

1. Dry compression.
2. Wet compression.
3. Oil circulation.

DRY COMPRESSION MACHINES.

The gas is compressed in a jacketed compressor, water is circulated through this jacket to remove, as much as possible, the heat produced by the compression.

WET COMPRESSION MACHINES.

With the gas a small portion of liquid is admitted into the compressor, which, being evaporated while the gas is compressed, through the heat so produced, accomplishes the same purpose as the jacket in the dry compressor, but in a much higher degree.

The best result will be obtained when just so much liquid is injected with the gas that the gas is barely saturated at the end of the compression, that is to say, there was liquid present up to the end of the stroke, but none to leave the compressor and enter the condensers, since all of the liquid has been evaporated by the heat of compression.

This result is, of course, not obtainable in practical work, as the danger of injecting liquid is too great. The injection is, therefore, kept safely within the theoretical bounds. This is controlled by the touch of the hand. As long as the temperature *of the gas, leaving the* compressor, is appreciably warmer than the

liquid leaving the condensers, there can be no liquid carried from the compressor, since it cannot exist at a higher temperature than that which prevails in the condenser.

The danger of injecting too much liquid is apparent. If liquid remains in the compressor after the completion of the compression stroke, it will fill the clearance existing in every compressor, and when the piston recedes to take in new gas, will prevent the entry of new gas until all the liquid which remained after compression has been evaporated. Assuming that the condensing pressure would be 156 pounds, and the suction pressure 27 pounds, the loss will be about 270 times the amount of the clearance, which may be assumed to be one-sixteenth of an inch. Or, for about 17" of the stroke, no new gas would enter. If, therefore, the stroke of the compressor was only 16", absolutely no new gas would enter during this stroke, and, of course, none would be discharged, and only half the refrigeration would be obtained.

OIL CIRCULATION.

The heat of compression is here removed by injecting cool oil instead of the liquid. The oil is injected during the compression period, and discharged with the gas into an oil tank, where part of the oil is retained, while the gas passes into the condenser. The oil is discharged into a separate cooler, and, after being cooled by the water, returned to the compressor. Any oil which has been carried with the gas into the condensers will run with the liquid into the liquid receiver, which is so arranged that the oil has time to separate from the liquid, being about 50 per cent heavier than the liquid. The pipe conveying the liquid from the liquid receiver to the cooling coils is inserted from the top of the tank and reaches down to about 12" above the center of the tank, leaving ample room for the oil to collect.

The other reasons why oil injection is used, are: The perfect lubrication obtained, the sealing of the valves, the filling of the clearances preventing re-expansion of any gas, and, finally, the sealing of the stuffing box in vertical compressors. This holds good, however, only for very slowly running machines, as otherwise the oil is not handled in bulk form.

The oil used for this purpose must not saponify, must have a congealing point of about 0°, and a flash point of about 360°, and should be light-colored and not too heavy.

The same oil is used for lubricating the dry and the wet com-

pressure and in the double stuffing boxes of the horizontal machines.

ABSORPTION MACHINES.

The principle of this machine is the ability of water to absorb gases, and the best for this purpose is ammonia.

One volume of water at 76° temperature absorbs 600 volumes of ammonia independent of the pressure under which both exist. It will therefore be seen that this absorption must be very energetic. The heat generated by the absorption of one pound of ammonia in water is 927 heat-units, or nearly twice as much as the heat of evaporation of ammonia, which is, on an average, 560 heat-units.

The process is as follows: The ammonia gas, after having been evaporated in the cooling coils, enters the absorber, which is a vessel provided with water-cooling coils for removing the heat of absorption. The ammonia is absorbed by the water contained in this vessel until a good, strong aqua ammonia is formed. This aqua is sent by a pump through a heat exchanger into the still. There, by means of steam coils, the strong aqua is heated, and the ammonia partly freed from it and sent into the condenser, where the ammonia gas is liquified and returned as a liquid to the cooling coils from which it came in the form of a gas. The aqua which remains in the still after having been deprived of all the ammonia gas possible, is allowed to flow back through the heat exchanger into the absorber. This is done by its own pressure, the pressure in the still being about 156 pounds, while the pressure in the absorber is about 27 pounds. This so-called weak aqua is now ready to absorb ammonia gas coming from the cooling coils.

The purpose of the heat exchanger is to reduce the temperature of the weak aqua, which is above the boiling point of water at atmospheric pressure, to the temperature of the strong aqua coming from the absorber and having a temperature of about 75°, the temperature of the absorber.

RELATIVE MERITS OF THE DIFFERENT SYSTEMS.

The *vacuum machine* can be dismissed as entirely impractical. It requires such enormous plant of vacuum pumps to do little work, and the difficulties to build a machine which will maintain such a high vacuum for any length of time, as well as the cost of power, which is much greater than required for the *air compression machine*, have caused it to fall into utter disuse.

The *air compression machine* has the disadvantage that the whole cooling effect obtained by it is produced by expending power, which means coal. The water in this machine simply takes away the heat produced by compression, so that the air is capable of reducing its own temperature while expanding to the desired low temperature. The amount of heat produced by compression, the amount of heat removed by the water, and the amount of heat abstracted from the air while expanding, are all of equal value.

It must be the aim, in an efficient and economical machine, to do most of the work by water and not by coal. Consequently one cannot economically employ a machine which requires fuel amounting to about five times as much as a machine using a liquifiable gas as a medium, while the capacity of the compressor must be forty-five times the capacity of a compressor using liquifiable gases.

The *Dense Air Machine* has only this advantage over the air compression machine, that its compressor can be of smaller capacity because it handles denser air, and the capacity of this compressor need be only nine times that of a compressor using a liquifiable gas. There is, however, no saving of power, and coal still has to do the whole work.

Regarding the economy of machines using the different *liquifiable gases* as media, there is little to say. Theoretically, the efficiency is the same for all, but practically, the nature of the different gases causes differences, and often determines the value of a machine charged with it.

The *ammonia compression machines* hold the market for the following reasons: Ammonia can be condensed and expanded at reasonable pressures. A leakage will be known soon by the strong smell. It is not injurious to health if not inhaled in excessive quantities. It has the highest latent heat in comparison to its specific heat, which is a quality always to be desired.

The objections to *sulphuric ether* are that the suction pressure is less than the atmospheric pressure and, consequently, air will enter the stuffing box of the compressor, producing a mixture of gases which is very explosive. Besides, it is very dangerous to inhale the gas.

The objections to *sulphur dioxide* are that the suction pressure *must be kept* so near the atmospheric pressure, and often goes *below it in the* practical handling of the machine, that air is

sucked into the compressor through the stuffing box, carrying moisture with it, and thus forming, with the sulphur dioxide, sulphuric acid, which will eat up compressor and pipes in short order.

The objection to *carbon dioxide* is the excessive pressures under which it must be handled, viz.: 381 pounds suction pressure and 1,065 pounds condensing pressure. For all gases the temperatures prevailing in the condenser have been taken as 86°, and in the cooling coils as 14°; therefore, the pressures given correspond to these temperatures. It is very difficult to get tight joints and stuffing boxes at such pressures. Moreover, since the temperature at which the gas refuses to liquify at any pressure—the so-called critical temperature of the gas, which is 89°—is so near the temperature of our cooling water which often is over 85°, it is dangerous to use this gas, and the condenser would be of small efficiency if working with a difference of temperature of only 4° between the gas and the water, while condensers are expected to work with a difference of temperature of at least 15°. If the water is only 85°, the machine employing this gas will work very unsatisfactorily, and, besides, will require enormous quantities of water, owing to the small amount of heat each pound can take off. The gas itself is hardly noticeable by the nose or ear, and when escaping might kill the engineer before he knew he had a leak. Besides, it is difficult to detect a leak.

It is claimed for this gas that it is cheap. But this need not make much difference, as ammonia joints can be made and kept tight. So it is only the first cost which could enter into this consideration.

It is further claimed that since the gas is heavy and at high pressure, the compressor need only be small, which is true, as one cubic foot of it weighs 4.535 pounds, while a cubic foot of saturated ammonia at the same temperature weighs only 0.147 pounds, and therefore the compressor of the carbon dioxide machine need have only one-thirtieth the capacity of an ammonia compressor. But, on the other hand, while one pound of liquid carbon dioxide furnishes 14.79 th. u., whereas one pound of liquid ammonia furnishes 500.35 th. u., which is more than thirty times the heat developed by the carbon dioxide, making up more than enough for the advantage in weight.

The objections to the ammonia absorption machines are quite

numerous. The handling of aquas of different strength, different temperatures and different pressures is work for a chemist, rather than an engineer. As long as the machine works regularly, there is no trouble. But the moment something unusual happens, it takes a good chemist to find the trouble. There have been many cases where a machine had stopped and many and good experts were present trying to start it again, but did not succeed, and when the engineer took the machine in hand again, after having left it alone for a while, it started as well as ever. It is impossible to see what is the trouble by opening the machine, like a compressor machine, and only the intelligent reading of thermometers and gauges, and testing of the weak and strong aqua at the different points, can reveal the trouble.

At the first glance it seems as if the absorption machine was the correct one to use steam for cooling, as the steam is used directly. But a little consideration of the action of the machine will show a great many drawbacks. The fact is that while an ammonia compression machine, with simple Corliss engine, can perform the work of twenty-seven pounds of ice melted, figuring thirty pounds of steam per horse-power per hour, an absorption machine using the best coal can only perform the work of seventeen pounds of ice melted.

The reason for this deficiency lies in the fact that the boiling in the still not only drives out the ammonia gas, but also evaporates some of the water, sending water vapor along into the condenser. The evaporation of this requires considerable heat. Furthermore, while ammonia, when evaporating in the cooling coils, abstracts only about 500 th. u., there are 927 th. u. required in the still to free the ammonia gas from the water. The condensation of this water vapor carried along requires extra water, and the absorber requires about twice as much water as the condenser, as 927 th. u. are transferred there to the water by the absorption of one pound of ammonia, while only 524 th. u. are abstracted by the water at the condenser. Nor can it be expected, owing to the water vapor carried in the condenser, to get perfectly anhydrous ammonia for the cooling coil, but considerable moisture will be found in it which impairs the efficiency of the ammonia materially.

When it comes to absorption machines working with water of 80° to 86°, much cannot be expected from them, as this temperature is close to the temperature at which ammonia practically

ceases to be absorbed by water. It is, therefore, advisable to use absorption machines only where plenty of cold water is at hand and coal is cheap.

USES OF REFRIGERATION.

All machines, except the air compression machines handling air at atmospheric pressure, and the vacuum machines, can be applied to all the different uses hereafter described. In describing the handling of machines, however, the ammonia compression machine will be kept in view as being the one most commonly used.

WATER COOLING.

Water is required to be cooled in a brewery, first, for the attemperators, and second, for cellar washing.

Cooling should never be done with the cooler submerged. The transmission of heat is proportionate to the thickness of the material it has to penetrate, the difference of temperature between cooling medium and the substance to be cooled, and to the velocity with which the material flows over the cooler. It is, therefore, wrong to submerge the cooler, as it will require about twenty times as much cooling surface as when the cooler is not submerged, but the water flowing over it.

The ammonia should enter the top of the cooler, because then the hottest gas or liquid will meet the hottest water, the same as in the Baudelot cooler, where the beer runs outside over the cooler from the top, while the cooling water enters the cooling coil at the bottom. This enables the wort and the water to exchange temperature in the most perfect way. If the cooler is about thirty-four pipes high and the proper amount of water—about 125 barrels of water for 100 barrels of wort—is supplied, the water will leave the cooler with a temperature about 6° lower than the beer. In the case of the ammonia water cooler the liquid, when entering, will have a higher pressure and, consequently, higher temperature than when it leaves the cooler, owing to the friction in the pipes. Furthermore, the liquid entering from the top will flow freely through the cooler, flowing downward, and will not fill the pipes so much as if forced upward, leaving, therefore, a larger space for the evaporating gas and facilitating evaporation, the same as a good steam space in a boiler. Care must be taken to turn on the water over the cooler at the same time as the ammonia is turned inside it, as otherwise the liquid

rushing through the cooler would find nothing to abstract heat from, and would fill the cooler rapidly, and finally the back frost would come back heavily to the machine.

It is very important to choose the proper suction pressure for water cooling, if this can be done without interfering with other work, for instance, when the cellars are shut off, or an extra machine with extra suction pipe leading to the cooler is at disposal.

It is always advisable to keep a difference of 8° to 10° between the temperature of the gas and liquid in the cooler, and the water to be cooled, provided that the cooler has sufficient surface to allow this without freezing back too much to the machine.

In the table giving the properties of saturated ammonia will be found the temperatures of the gas corresponding to respective pressures. For instance, when cooling water to 40°, a suction pressure of 45 pounds is advisable. The temperature of the gas at this pressure is 31°, as per table, and therefore we have a difference of 9° between water and gas; it is not advisable to use a suction pressure higher than 45 pounds for the reason that the gas would have a temperature above 32°, and the ammonia pipes could not show frost, depriving the operator of the only means by which he can regulate the flow of the ammonia. In this case, and if water is to be cooled to, say 50°, a suction pressure of 60 pounds could be carried and good work done, but in order to regulate the flow of the ammonia properly, an ammonia gauge must be connected to the suction pipe so that the operator can regulate by its readings.

Another disadvantage will be encountered when using submerged coolers, viz., the forming of thick ice on the cooler which acts as a non-conductor, and reduces the efficiency of the cooler.

The attemperator cooler is nothing but a regular water cooler. But if used little it is not objectionable if ice forms on the cooler. The work of this cooler is of necessity very irregular, owing to more or fewer attemperator coils being supplied by it, and it should be of the right size to prevent the frost coming back to the machine too strong when used to its full capacity. It must be expected that ice will form when it is used to about one-half its capacity.

The attemperator coils in tubs are made preferably of black iron pipe of 2" diameter, the coil having one convolution, and elbows

[redacted]

reduced to ¾″ are placed at its ends about 3″ apart, the outside diameter of the coil to be 6″ smaller than the inside diameter of the tub at the top, and the coil hung 18″ from the top of the tub by three *S* hangers. Each coil should be provided with two valves and unions for disconnecting.

The attemperator pump should be placed about 20 feet below the fermenting room, and the attemperator tank above the fermenting room, and placed in an insulated enclosure if the room above the fermenting room is not cooled. This arrangement is necessary to provide for the automatic starting and stopping of the attemperator pump.

Attemperator Pump.—The speed of the pump is regulated, or it is started or stopped, by the weight of the water column in the return pipe from the attemperator mains in the fermenting room to the pump, by means of a pressure regulator attached to the return pipe and connected to a balanced regulating valve placed in the live-steam pipe of the pump. The return pipe should be large enough to prevent its filling at any time so that the water column can regulate without interruption.

If the pump runs too fast, the water column in the return pipe will get shorter and exert less pressure upon the pressure regulator, and the latter will act upon the steam regulating valve, reducing the inflow of the steam, and with it the revolutions of the pump, stopping it entirely when all the water is out of the return pipe, and starting the pump again as soon as water collects in the return pipe, which will occur even if only one attemperator coil is turned on. To place the tank above the fermenting room will also prevent excessive pressure in the mains, as the water flows only by gravity to the coils.

To cool water for cellar washing, the beer cooler can be used when not needed for wort cooling. The water can be run into a big tub and stored there ready for use. This will also prevent waste of cooling power, as the use of the water for this purpose can plainly be seen, and the amount of work required by the machine measured, which is very necessary, as otherwise enormous quantities of refrigeration may be wasted.

Beer Cooler.—All that has been said about the water cooler applies also to the beer cooler. It should only be remembered that cooling wort with ammonia means much work, and therefore all possible cooling should be done by the water section, which should have at least 34 pipes.

It takes, approximately, one ton of refrigeration to cool 100 barrels 10°, and 80 barrels can be run safely over a cooler of 20 feet length.

The ammonia part of the beer cooler should be made of two-inch, smooth wrought-iron pipe, well polished. This kind will give the best results. The old method of using copper-covered wrought-iron pipe cannot be recommended, because it is impossible to draw copper tubes over iron tubes so tightly that there will be no air space between them. Air space strictly confined, as in this case, is the best non-conductor for heat known. It has been found at times by sounding with a light hand hammer that two-thirds of the pipes were thus put out of action.

There is no danger of affecting the wort by rust, when the pipes are coated with a good varnish; besides, the wort will form a crust, which will thoroughly protect the iron.

The beer cooler should always be made of ample height, as this will allow the machine to work with the most economical suction pressure and will prevent excessive back frost.

Copper drip strips should be soldered to the ammonia pipes and brass clamps used in the middle. Iron clamps will do for the ends, but these end clamps should be placed on the fittings and not on the pipes, so that the beer will not strike them and form ice. Lately, the entire beer cooler, the water part, as well as the ammonia part, have been made of polished iron pipe, which is preferable, as it is conducive to cleanliness, no verdigris can form, and cleaning is an easy matter. But, owing to the thickness and the difference in conductivity of iron, about 50 per cent more pipes should be used for the water part than for copper pipes.

CELLAR COOLING.

There are two methods:

1. Direct expansion.
2. Brine circulation.

DIRECT EXPANSION.

In this system the ammonia comes directly in contact with the air, being circulated in wrought-iron pipes located in the *rooms to be cooled*. This is the best method, because it is *direct*. *In order to* cool air in a room by pipes to 32° the gas

in the pipes must have a temperature of 14° to 20°, according to the amount of pipes provided to do a certain work, and whether the pipes are supplied with discs or not. To work with a less difference in temperature will not pay, as the first cost of the pipes, the extra amount of ammonia required, and the extra friction of the gas in the pipes will more than counteract the gain in the coal pile.

That pipes provided with discs cannot do good work with a small difference in temperature is plain from the fact that the cooling effect has to extend from five to seven inches from the center, and to spread out over a large surface, while in pipes without discs the distance it has to travel is small, being about three-sixteenths of an inch, and the surface it has to supply is very small also. If there was too little difference of temperature allowed in pipes supplied with discs, their edges would drip continually, which cannot be permitted as it would make the air in the cellar moist.

Discs should not be used any more. It paid to extend the surface of the pipes by means of discs when ammonia was worth $1.50 and $1 per pound, as it was cheaper then to put up less piping and to use only one-half the amount of ammonia by placing discs on the pipes. But at present, with ammonia at 25 cents, the saving would amount to about four cents, while the disc would cost at least 25 cents.

This calculation is per foot of pipe, one foot of two-inch pipe requires one-third pound of ammonia, and if discs are used, one is provided for each foot of pipe.

If we would circulate brine through the pipes the brine must, from the above considerations, have a temperature of 20°, and in order to obtain brine of such temperature we must keep the temperature of the gas much lower than 20°, which can be done if we apply refrigeration directly. It should be at least 12°. But this necessitates a lower suction pressure, about 25 pounds, for the machine, while with direct expansion we can work with 30 pounds and without discs with 35 pounds if sufficient piping is provided. Now, five pounds' less suction pressure means 12 more revolutions per minute, and 12 per cent more coal, and 10 pounds double as much, which is certainly a matter worthy of *consideration*.

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Two-inch cooling coils should always be used, and no run connected to one expansion cock should be longer than 200 feet. The returns should be made of pipe, and have 10-inch, or better still, 15-inch centers. The suction mains leading to the machines should be of such size that the gas will never be crowded on its way to the machine, as this would decrease the suction pressure by the friction in the pipes, and, consequently, reduce the capacity and efficiency of the machine. If the suction inlet to the machine is three inches, and there is one double-acting compressor, the main suction pipe should be at least four inches diameter, or about 50 per cent larger, and the branches from the main pipe should be made of such area as is in proportion to the number of feet of pipe supplied by each, their total area being equal to the area of the main suction or more.

If there are more compressors, the suction-pipe area must be increased in proportion to their number.

On all lowest point of the main suction pipe and its branches drips should be provided, to be able to drain water and oil, should such accumulate, and a good-sized drip tank should be set up to drain the lowest part of the main suction pipe by gravity. This tank should always be in connection with the suction pipe, and will give warning as soon as too much oil or water accumulates, because the frost which always covers this tank, as long as only gas and liquid is in it, will then thaw, and the part uncovered will indicate the amount of water or oil accumulated, which should be drawn off as soon as the tank is half filled.

BRINE CIRCULATION.

The brine is cooled in a large tank, which may be located in the engine room or close to the machine. This tank is filled with heat-absorbing pipes, preferably of two inches' diameter, as they will not choke up so easily with scales and oil. There should be at least 110 feet of pipes provided for each ton of refrigeration, if two-inch pipes are selected. Not to exceed 500 feet should be connected to one expansion cock, and the brine pump, which is to be brass fitted, should be of such size that when each piston makes 60 strokes per minute it will deliver 12 gallons of brine per ton of refrigeration. This will bring the brine back to the tank, with a temperature 2° higher than when it left the tank, and is considered good practice.

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The pump should be provided with suction and discharge valves. A strainer should be put in the suction pipe, so arranged by means of a by-pass and valves that it can be taken out while the pump is running. A thermometer should be inserted in the suction pipe, so that it can be removed when broken without stopping the pump. The return pipe should be so placed in the tank that good circulation will ensue. It should enter the tank at the opposite corner of the tank from where the suction is located, which should be put near the bottom, and a header might be put on the discharge pipe with openings to force the brine along each cooler.

TABLE OF BRINE SOLUTION.

(Chloride of Sodium—Common Salt)

Percentage of Salt by Weight.	Degrees on Salometer at 60° F.	Specific Gravity of 60° F.	Specific Heat.	Weight of One Gallon.	Pounds of Salt in One Gallon.	Pounds of Water in One Gallon.	Weight of One Cubic Foot.	Pounds of Salt in One Cubic Foot.	Pounds of Water in One Cubic Foot.	Freezing Point, Degrees F.
0	0	1.	1.	8.35	0.	8.35	62.4	0.	62.4	32.
1	.4	1.007	0.992	8.4	0.084	8.316	62.8	0.628	62.172	31.8
5	20	1.037	0.96	8.65	0.432	8.218	64.7	3.237	61.465	25.4
10	40	1.073	0.892	8.95	0.895	8.055	66.95	6.695	60.253	18.6
15	60	1.115	0.855	9.3	1.395	7.905	69.57	10.435	59.131	12.2
20	80	1.150	0.829	9.6	1.92	7.68	71.76	14.352	57.408	6.86
25	100	1.191	0.783	9.94	2.485	7.455	74.26	18.565	55.695	1.00

The brine mains supplying the coils in the cellars should be so arranged that the brine leaving each cellar coil must rise to a point higher than the coil in the highest cellar, so as to equalize the pressure in each coil in the different stories. A vacuum breaker must be provided on top of the return pipe to prevent it being siphoned out. The pipe headers in the cellars must be of ample size to accommodate the quantity of brine delivered by the discharge pipe, the size of which is determined by the discharge opening of the pump, which should never be reduced.

Each coil of pipes connected to the discharge header in the cellars should be provided with a good valve of the size of the coil, and no more than 120 feet of one-inch pipe, and no more than 240 feet of two-inch pipe should be connected to one valve. *Air vents should be* provided for each header.

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The brine tank, the brine pump and brine mains should be well insulated wherever exposed to warm air.

It is advisable to use brine circulation only for small rooms, ice boxes, where there are only few pipes required and where it would be difficult to regulate the expansion, as the gas would have to travel such short distance, or if it is desired to run the machine in the daytime only, and the brine pump only at night. In the last mentioned case refrigeration can be stored by the brine tank, if it is made big enough, which, however, is very expensive, as brine tank, brine coils and machine must be twice the size that they would be for direct expansion.

PROPERTIES OF SOLUTION OF CHLORIDE OF CALCIUM.

Percentage by Weight.	Specific Heat.	Specific Gravity at 60° Fahr.	Freezing Point, Degr. F.	Freezing Point, Degr. C.
1	0.965	1 009	31	−0.5
5	0.964	1.043	27.5	−2.5
10	0.896	1.087	22	−5.6
15	0.860	1.134	15	−9.6
20	0.834	1.182	+5	−11.8
25	0.790	1.234	−8	−22.1

It is often claimed that brine circulation affords a safeguard against accidents, that the machine can be stopped for some time, and yet the brine will be cold enough to do work. But, first, the brine tank must be very large to do this, and when the machine is in order again, it must first cool the brine, working for hours before the brine can be used for refrigeration. In the direct expansion system, on the other hand, there is abundant storage of cold in the ice covering the pipes, which will last for almost 24 hours, if it has been allowed to accumulate, as is nearly almost the case, and when the machine is again ready for work, refrigeration will start at once.

ICE-MAKING.

Ice-making is another practice which is coming more and more into favor in breweries, on account of the small expense incurred in making it in connection with a brewery plant. The same machine which is used for beer cooling and cellar work can be used for ice-making, provided there is spare capacity and sufficient boiler power.

In ice plants of reasonable size, provided with a good Corliss *engine, there is not* sufficient exhaust steam furnished by the *machine to supply* the amount of distilled water required for

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ice-making. It is generally necessary to add 25 per cent of live steam, which has done no work, to the exhaust in order to supply this deficiency. Now, the brewery has an abundance of exhaust on hand, and, therefore, does not have to pay for this additional live steam. It also has the required engineers and firemen, so that their wages need not enter into the calculation. The expense, therefore, will consist only in the extra amount of coal and the wages of the ice pullers.

Figuring only coal and labor to deliver the ice in the store room, ice can be made with a 40-ton plant at 25 cents a ton.

The freezing of the ice is done in a big tank filled with brine and containing rows of pipes, through which ammonia is circulated, and between which galvanized cans are placed. The brine is circulated in the tank itself by a propeller. The water used for filling the cans is obtained by condensing the exhaust steam, reboiling, filtering thoroughly and cooling it. This is done to expel all the air and remove all impurities, as oil, rust, etc. It is necessary to remove the air from the water, as otherwise it would be caught while the ice is frozen, and the product would have a milky appearance.

For each ton of ice made there should be furnished 260 feet of two-inch pipe, and sufficient cans to freeze blocks of 11x22 by 42 inches, and 60 hours for freezing. Thus, a 40-ton ice plant would require 667 cans. The temperature of the brine in the freezing tank should be 18°.

It is very important that the freezing tank be well insulated, and that the cans are straight and not twisted, and have the proper taper for releasing the ice. A can which will furnish 300-pound blocks should measure at the top 11½ by 22½ inches, and at the bottom 21¾ by 10¾ inches to make a full-size block.

The strength of the brine need not be higher than necessary to prevent its freezing at the temperature required. Stronger brine does not help freezing; it only lowers the freezing point.

It is generally believed by engineers that stronger brine does better work. This is based upon the observation they have made that they succeed in lowering the temperature of the brine in a given tank with a given machine quicker when the brine is strong than when it is weak, which is quite true. But they have done equal amounts of work in both cases, as will appear from the following reflection:

One ton of refrigeration will cool 28,400 pounds of water 10°, while it will cool an equal number of pounds of brine of 26 per cent 12.5°, because the specific heat of this brine is only 0.8 of that of water, which is = 1. It is evident, therefore, that nothing has been gained. While it is easier to lower strong brine one degree, the same brine will heat up so much quicker. If it is, therefore, a matter of storing refrigeration, the brine should be made only strong enough to prevent its freezing.

If, for instance, it is desired to store refrigeration in the most economical way and requiring the smallest possible tank, it is best to place large galvanized cans between the coils in the tank and to fill them with brine of different strength, say, 5 per cent for the first one, 10 per cent for the second and 15 per cent for the third. Then the can containing the weakest solution will freeze first, next the 10 per cent one, and, finally, the 15 per cent one. In this way the work is done at the highest possible suction pressure and the ice stored instead of brine, which is about as 1 to 14 in capacity. This system was invented and patented by Mr. George Richmond.

PRACTICAL TESTS FOR MATERIAL USED WITH REFRIGERATING MACHINES.

AMMONIA.

Fill a pint Venetian boiling flask about one-half full with liquid ammonia, put a rubber cork in the opening, and insert a small glass tube projecting a few inches below the cork, but not so low that the ammonia, when boiling, can strike it. Set the bottle in a place of ordinary temperature where the sun will not fall upon it. The ammonia should leave no trace, if pure and anhydrous. Sometimes it will leave a trace of oil, which, if very little, will not be objectionable, but water should not be found after the ammonia has all evaporated.

To fill the bottle, it is best to make a fork of wood to hold the bottle neck, and to fasten the bottle securely with a string. The piece of wood should be at least 24 inches long for safe handling. Place the bottle so that when the liquid runs out of the valve of the shipping tank it will run into the bottle without spilling. The tank must be raised high enough so that the bottle can stand upright under the valve. Open the valve

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very little, and a white vapor of evaporating liquid will appear, which must evaporate first in order to cool the valve, so that the liquid can exist as such under atmospheric pressure. It creates a temperature of — 27° while thus evaporating. Soon, the liquid will follow in a thin jet, but the filling must be done very slowly, as otherwise the bottle will burst. The kind of bottle described is used because it is made of very thin glass and will stand a great change of temperature. The cork and glass pipe is provided to prevent moisture entering through the mouth of the bottle.

A glass thermometer kept submerged in the liquid should show — 27° if the ammonia has not been mixed with another liquid, which has been known to occur.

AMMONIA OIL.

Ammonia oil should not be too dark, so that it can be easily seen in the gauges. It should be about 26° Beaumé, as otherwise it would be too sluggish, and it should not congeal in brine, or in a freezing mixture more than one or two degrees above zero. If a brine tank is at hand it is safe enough to put a sample of the oil in the brine, and if it does not congeal in the course of a couple of hours, it is safe to use.

The oil must not flash much below 360°, which can be ascertained by heating it over a gas flame in a little tin pot, stirring it all the while, and moving a very small gas flame close over its surface, so as to ignite any gas which may be formed. Whenever gas forms the flash point is reached, and can be read from a glass thermometer which is held in the fluid, and at the same time can be used for stirring.

SALT.

The salt when dissolved should show no residue, or at least very little, and when heated for an hour at a moderate temperature should not lose weight, as such loss would indicate that it contains considerable water. It is material to know this, so as not to pay for water if salt is wanted. Rock salt is usually the most reliable. Evaporated salt might contain a great amount of water.

Properties of Different Liquids Used in Refrigerating Machines.

Boiling Point Degrees Fahr.	Tension of Vapor in Pounds per Square Inch Above Zero.					
	Sulphuric Ether.	Sulphur Dioxide.	Ammonia.	Methylic Ether.	Carbon Dioxide.	Pictet Fluid.
—40	......	......	10.22	......	......	....
—31	.....	......	13.23	......	......	....
—22	......	5.56	16.95	11.15	......	....
—13	......	7.23	21.51	13.85	251.9	....
—4	1.30	9.27	27.04	17.06	292.9	13.5
+5	1.70	11.76	33.67	20.84	340.1	16.2
14	2.19	14.75	41.58	25.27	393.4	19.3
23	2.79	18.31	50.91	30.41	453.4	22.9
32	3.55	22.53	61.85	36.34	520.4	26.9
41	4.45	27.48	74.55	43.13	594.8	31.2
50	5.51	33.26	89.21	50.84	676.9	36.2
59	6.84	39.93	105.99	59.06	766.9	41.7
68	8.38	47.02	125.05	69.35	864.9	48.1
77	10.19	56.30	146.64	80.28	971.1	55.6
86	12.31	66.37	170.83	92.41	1085.6	64.1
95	14.76	77.64	197.83	.....	1207.9	73.2
104	17.59	90.32	227.76	.....	1338.2	82.9

Solubility of Gases in Water at Atmospheric Pressure

1 Vol. Water Dissolves Vols. Gas.	32° F.	39.2° F.	50° F.	60° F.	70° F.
Air..................	0.0247	0.0224	0.0195	0.0179	0.0171
Ammonia..........	1049.6	941.9	812.8	727.2	654.0
Carbon Dioxide.	1.7967	1.5126	1.1847	1.0020	0.9014
Sulphur Dioxide..	79.789	69.828	56.647	47.276	39.374
Marsh Gas.........	0.0545	0.0499	0.0437	0.0391	0.0350
Nitrogen	0.0204	0.0184	0.0161	0.0148	0.0140
Hydrogen	0.0193	0.0193	0.0191	0.0193	0.0193
Oxygen............	0.0411	0.0372	0.0325	0.0299	0.0284

Strength of Ammonia Liquors.

Per Cent. Ammonia by Weight.	Specific Gravity.	Degrees Beaume Water 10.	Degrees Beaume Water 0.	Per Cent Ammonia by Weight.	Specific Gravity.	Degrees Beaume Water 10.	Degrees Beaume Water 0.
0	1.000	10	0	20	0.925	21.7	11.2
1	0.993	11	1	22	0.919	22.8	12.3
2	0.986	12	2	24	0.913	23.9	13.2
4	0.979	13	3	26	0.907	24.8	14.3
6	0.672	14	4	28	0.902	25.7	15.2
8	0.966	15	5	30	0.897	26.6	16.2
10	0.960	16	6	32	0.892	27.5	17.3
12	0.953	17.1	7	34	0.888	28.4	18.2
14	0.945	18.3	8.2	36	0.884	29.3	19.1
16	*0.938*	*19.5*	9.2	38	0.880	30.2	20.0
18	*0.931*	*20.7*	10.3				

PROPERTIES OF SATURATED AMMONIA GAS.

De Volson Wood and Geo. Davidson.

Gauge Pressure, lbs. per Square Inch.	Absolute Pressure, lbs. per Square Inch.	Temp. Degrees F.	Absolute Temp. Degrees F.	Latent Heat of Evaporation in Thermal Units.	Volume of 1 lb. Vapor in Cubic Feet.	Weight of One Cubic Foot of Vapor in lbs.	Volume of 1 lb. of Liquid in Cubic Feet.	Weight of 1 Cubic Foot of Liquid in lbs.
—4.01	10.69	—40	420.66	579.67	24.38	0.0410	0.0234	42.589
—2.39	12.31	—35	425.66	576.68	21.32	0.0469	0.0236	42.337
—0.57	14.13	—30	430.66	573.69	18.69	0.0535	0.0237	42.123
+1.47	16.17	—25	435.66	570.68	16.44	0.0608	0.0238	41.858
3.75	18.45	—20	440.66	567.67	14.51	0.0690	0.0240	41.615
6.29	20.99	—15	445.66	564.64	12.83	0.0779	0.0241	41.374
9.10	23.80	—10	450.66	561.61	11.38	0.0878	0.0243	41.135
12.22	26.92	—5	455.66	558.56	10.12	0.0988	0.0244	40.900
15.67	30.37	0	460.66	555.50	9.03	0.1107	0.0246	40.650
19 46	34.16	+5	465.66	552.43	8.07	0.1240	0.0247	40.404
23.64	38.34	10	470.66	549.35	7.23	0.1383	0.0249	40.160
28.24	42.94	15	475.66	546.26	6.49	0.1541	0.0250	39.920
33.25	47.95	20	480.66	543.15	5.84	0.1711	0.0252	39.682
38.73	53.43	25	485.66	540.03	5.27	0.1897	0.0253	39.432
44.72	59.42	30	490.66	536.91	4.76	0.2099	0.0255	39.200
51.22	65.92	35	495.66	533.78	4.31	0.2318	0.0256	38.940
58.29	72.99	40	500.66	530.63	3.91	0.2554	0.0258	38.684
65.96	80.66	45	505.66	527.47	3 56	0.2809	0.0260	38.461
74.26	88.96	50	510.66	524.30	3.24	0.3084	0.0261	38.226
83.22	97.92	55	515.66	521.12	2.96	0.3380	0.0263	37.994
92.89	107.59	60	520.66	517.93	2.70	0.3697	0.0265	37.736
103.33	118.03	65	525.66	514.73	2.48	0.4039	0.0266	37.481
114.49	129.19	70	530.66	511.52	2.27	0.4401	0.0268	37.230
126.52	141.22	75	535.66	508.29	2.09	0.4791	0.0270	36.995
139.40	154.10	80	540.66	505.05	1.92	0.5205	0.0272	36.751
153.18	167.88	85	545.66	501.81	1.77	0.5649	0.0273	36.509
167.92	182.62	90	550.66	498.55	1.64	0.6120	0.0275	36.258
183.65	198.35	95	555.66	495.29	1.51	0.6622	0.0277	36.023
200.42	215.12	100	560.66	492.01	1.39	0.7153	0.0279	35.778
218.28	232.98	105	565.66	488.72	1.289	0.7757	0.0281	......
237.27	251.97	110	570.66	485.42	1.203	0.8312	0.0283	......
258.7	272.14	115	575.66	482.41	1.121	0.8912	0.0285	......
275.79	293.49	120	580.66	478.79	1.041	0.9608	0.0287	......
301.46	316.16	125	585.66	475.45	0.9699	1.0310	0.0289	......
325.72	340.42	130	590.66	472.11	0.9051	1.1048	0.0291	......
350.46	365.16	135	595.66	468.75	0.8457	1.1824	0.0293	......
377.52	392.22	140	600.66	465.39	0.7910	1.2642	0.0295	......
405.79	420.49	145	605.66	462.01	0.7408	1.3497	0.0297	......
435.5	450.20	150	610.66	458.62	0.6946	1.4396	0.0299	......
466.84	481.54	155	615 66	455.22	0 6511	1.5358	0.0302	......
499.70	514.50	160	620.66	451.81	0.6128	1.6318	0.0304	......
534.34	549.04	165	625 66	448.39	0.5785	1.7344	0.0306	......

One atmosphere in this table is equal to **a** pressure of a column of mercury **29.9** inches high.

Specific heat of ammonia gas and vapor at constant pressure..= 0.508

The same at constant volume................................. .= 0.3913

Weight of 1 cubic foot liquid ammonia at 32° **Fahr**.... ....=39.108 lbs.

Volume *of 1 lb liquid* ammonia at 32° Fahr......................= 0.02557cu. ft.

Specific heat of *liquid* ammonia.......... ....=1.01235 + 0.008378t.

OPERATING REFRIGERATING MACHINES

SPEED.

Run the machine as slowly as possible to do the work necessary. This will insure prompt seating of the valves, reduce wear and tear and breakage.

STEAM PRESSURE.

Carry the steam pressure as high as the safety valve will permit. The higher the pressure, the greater the economy in fuel. The total heat of steam, that is, the amount of heat-units necessary to produce one pound of steam from water at 32°, is = 1180.3 for 80 pounds' gauge pressure, or 95 pounds' absolute pressure, and for steam of 125 pounds' gauge pressure = 1189.0. Or, it takes only 8.7 heat-units more to produce steam of 125 pounds than to produce steam of 80 pounds, which is an increase in fuel of only three-fourths per cent, while the gain in power in the steam cylinder increases in direct proportion to the increase of the absolute pressures, or, the gain is as 95 to 140, or 47 per cent. It is true the flue gases leave the boiler at a higher temperature, and, therefore, each pound of coal cannot yield quite so much heat. But this is a small amount, and could be used for heating the feed water, thus avoiding loss.

SUCTION PRESSURE.

The suction pressure should be carried as high as possible. The work which the machine has to perform, the temperatures it has to produce, and the amount of cooling pipes in which the work has to be done, determine the suction pressure. The best practical method is to try to raise the back pressure gradually from 25 pounds upward, until the machine fails to produce the required cooling effect, and then to keep the suction pressure a little below it.

To show what influence the suction pressure has on the efficiency and capacity of the machine, we need only consult the absolute pressure, which is obtained by adding 15 pounds, or the pressure of the atmosphere, to the gauge pressure. The capacity of the machine increases and decreases in direct proportion to the increase or decrease of the absolute pressure, for practical purposes. If we want to compare the capacity of a certain machine working at 15 pounds' gauge pressure, with the capacity of the same machine when working with 35 pounds'

gauge pressure, we have: $(15 + 15) : (35 + 15) = 30 : 50$, or, an increase of 66 per cent in capacity. Thus, we can run the machine with 30 revolutions at 35 pounds' suction pressure, while we have to run the same machine at 50 revolutions when working with 15 pounds' suction pressure. The coal consumption is increased only 10 per cent in this case. For pressures from 25 to 45 pounds the increase in coal consumption is practically nothing.

CONDENSING PRESSURE.

In order to reduce the coal consumption it is necessary to keep the condensing pressure as low as possible, since the higher the pressure, the more work must the machine perform, the pressure against the compressor piston being higher.

This pressure is determined, in the first instance, by the temperature and quantity of the water at disposal, and, secondly, by the amount of condensing surface. The condition of the condensers, whether clean or not, and their location, whether exposed to an air current or not, has also a great deal to do with their efficiency.

It is not proper to figure how many feet of pipe are in a condenser, but how many stacks, assuming that submerged condensers are out of the question, owing to their low efficiency. Tests have shown that in a stack only about twelve pipes actually do any condensing. The remainder act partly as storage and partly as air cooler for the water running over the condensers. So, the condensers may be 12 pipes high for the purpose of condensing simply, but it is desirable to make the condenser 18 pipes high, for the purpose of storing liquid ammonia, and for cooling the water by air to some extent.

For about 12 tons of refrigeration there should be furnished one stack made of two-inch pipe. The water required for one ton of refrigeration is, for well water of 56°, one gallon, and for river water of 85°, two gallons. It is the duty of the engineer to see that his condensers are kept scrupulously clean, that the water is distributed evenly over the condensers, and each condenser receives an equal amount of water.

When stopping the machine while the water has run over the condensers as usual for about an hour, the engineer should read the *condensing pressure* indicated by his gauge, and take *the temperature of the* water running over the condensers, then

by referring to the table giving the properties of saturated ammonia, he can see whether they correspond or not. If not, there is air in the system, which must be expelled, until the above mentioned readings correspond with the table. Air, not being compressible under pressures used in these machines, it mixes with the ammonia gas which fills the condenser. Besides, the gas and the air join so perfectly that the air cannot be separated from the ammonia by simply blowing it off at the top of the condenser. Such a proceeding would only waste considerable ammonia and not expel all the air. The only way is to confine the air above the liquid in the condenser by liquifying all that is possible, when only pure air can fill the top part of the condenser.

This is done as follows: First, ascertain how much liquid is in the whole system, so as to determine how many stacks of condensers can be filled at the time. Remember that each foot of two-inch pipe when filled contains about two-thirds of a pound of liquid. Drain the liquid from those condensers which you do not intend to purge at present, shut them off from the system, closing all valves or cocks leading into them, then close the liquid valves of the condensers you want to purge, and open their equalizing cocks, keeping the blow-off cock closed. Now start the machine, not too fast, as you are working with reduced condenser capacity and will soon fill the condensers which are connected, thus reducing the condensing surface still further.

The pressure will rise gradually and should not be allowed to go higher than 250 pounds. When this pressure is reached, the machine should be stopped, and if the pressure drops again, started slowly till again 250 pounds is reached, and, after stopping, the pressure will not drop much. Generally before 250 pounds' pressure is reached, the hand of the gauge will move in jerks. This is a sure sign that the air is confined, as only a non-compressible gas acts this way. When the machine is stopped, close the inlet valves of condensers, and open the blow-off valve very little, the water running all the time over the condensers.

As long as there is any air in the condenser no odor of ammonia is perceptible at the blow-off cock. As soon, however, as ammonia escapes and the valve gets cold all air has been removed. When this is observed, close the valve and examine the pressure

gauge. If pressure and temperature correspond, which is found by consulting the table, then proceed with the rest of the condensers in the same manner.

There has been a case where a plant did not work properly, notwithstanding the fact that everything was apparently in order, the ammonia was tested and found good, there was sufficient ammonia in the system, and no air in the condensers. But when the main supply of the liquid was shut off and the cooling coils pumped out, it was found that the suction pressure went down quicker than could be expected, and that the condenser pressure went down instead of up, which is not to be looked for in a plant working properly, since when pumping out, the condensers must be filled with liquid and the available condenser surface thereby reduced, and, therefore, the pressure increased. When the machine was stopped, the water still running over the condensers, the condensing pressure went far below the pressure due to the water, showing, conclusively, that something else besides ammonia was in the system. It has not yet been determined what it was, but it must have been another liquifiable gas, which condensed at a lower pressure than ammonia. The effect of this additional gas on the system was a material reduction in the cooling power of the machine. It pays to repeat the above experiment when no other cause for the bad working of the machine can be found.

The trouble was cured by proceeding just as for the purging of air and blowing off the undesirable gas, which burned with a yellow flame when a lighted torch was brought near it, while ammonia burns with a blue flame when treated in that way.

INFLUENCE OF HIGH CONDENSING PRESSURE ON EFFICIENCY AND CAPACITY.

In the first place, the higher the pressure, the higher is the temperature of the liquid and, therefore, a larger part of the liquid condensed must be spent to cool the remainder before it can do any cooling. For every degree the liquid is warmer, one thermal unit is wasted, or, since the total amount of heat obtainable from one pound of liquid is about 500 heat units, 0.2 per cent is wasted per degree. The loss for an increase from 150 pounds to 200 pounds therefore corresponds to an increase of temperature of the liquid from 86° to 100° = 14°; 0.2×14 = *2.8 per cent.*

But the loss in efficiency is much greater than the work of compression is, in this case, increased 19 per cent, which means 19 per cent more coal, harder work for the machine, and increased wear and tear.

BACK FROST.

It is well known that saturated gas is heavier than is superheated. Saturated means in contact with liquid but not containing liquid; superheated means that the temperature of the gas is higher than due to the pressure of saturated gas. Superheating takes place when gas leaves a water or beer cooler which is not frosted completely. The gas will then be heated by the water or beer possibly as high as the temperature of the warmer liquid. For instance, in the beer cooler, where the temperature of the gas may be 20°, the beer is 40° when it leaves the cooler, and may, therefore, heat the gas 20°. This increases the volume of the gas per pound and, therefore, each pound of gas entering the machine weighs less, and the machine produces less pounds of liquid and does less cooling. A second cause of superheating is the heating of the gas in the suction pipes leading to the machine, if they are not efficiently protected by insulation.

It must be the aim of the engineer to get the gas to his machine in a saturated condition, as the small possible gain in cooling which he may get by superheating is more than counterbalanced by the loss in the capacity of his machine.

It is now universally admitted that wet compression is the correct principle. Hence, there should be enough back frost to the machine to cause the discharge pipe to be only about 20° to 30° warmer than the pipe carrying the liquid from the condensers to the liquid receiver. The advantages of this arrangement have been explained while describing wet compression. Something may be added here about the question of power. Owing to the high heat generated during compression in a dry compression machine, which is very unsatisfactorily carried off by the water in the water jacket of such compressor, the volume of the gas is considerably increased during compression, and more power is, therefore, required than if the heat is almost perfectly removed, as in the wet compression *compressor and* the oil circulation compressor. The com*pression curves produced* by both of the latter are almost identical,

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while the compression curve of the dry compressor rises much more rapidly.

It has been claimed that when liquid expands while the gas is compressed it must necessarily increase the volume of the gas in the compressor. While this is true, yet the curve is the same as the curve produced by injecting oil, because the oil does not cool the gas so much as the liquid does, and, therefore, this defect does not exist.

EFFECT OF BAD AMMONIA AND OIL ON THE PLANT.

Ammonia which contains water has not the refrigerating power which anhydrous ammonia has. It loses just as much of its power as there are per cent of water in it. Moreover, the water accumulates in the coils and prevents the free passage of the ammonia in places where water can collect, and prevents the pipes from transmitting heat where it locates. Besides, when paying for ammonia it is not pleasant to receive water instead.

The oil, if it contains animal oil, will saponify, clog up the pipes and expansion cocks, coat the inside of the pipes with a non-conductor, and be very hard to remove. Care must be taken, if oil circulation is not used, to use as little oil as possible for the lubrication of the compressor. Generally in horizontal machines sufficient oil is forced into the compressor from the double oil-sealed stuffing box to make any other compressor lubrication unnecessary.

Freezing back too much, so that the discharge pipe is almost or quite as cool as the liquid pipe, has another disadvantage, namely, that the piston rod getting very cold carries too much oil into the compressor which again brings it into the system, necessitating a frequent removal and the supplying of new oil for the stuffing box lubrication.

AMOUNT OF AMMONIA REQUIRED FOR A PLANT.

Allow for

One 10-ton machine..............	200 pounds
One 15-ton machine..............	250 pounds
One 25-ton machine.............	350 pounds
One 35-ton machine.............	400 pounds
One 50-ton machine.............	450 pounds
One 65-ton machine.............	500 pounds

One 100-ton machine............	580 pounds
One 150-ton machine............	680 pounds
One 200-ton machine............	780 pounds
One 300-ton machine............	1,080 pounds
One 400-ton machine............	1,380 pounds

and for each foot of two-inch cooling pipe, one-third of a pound of ammonia.

AMOUNT OF REFRIGERATION REQUIRED FOR A BREWERY.

For western conditions, allow one ton of refrigeration for 10,000 cubic feet of space in fermenting room, stock cellar, racking room and hop room, when figuring on the whole plant, and using this figure as an average. For the cooling of the daily brew, estimate the required refrigeration as follows: Multiply the number of barrels of the brew by the number of degrees the ammonia cooler must take out, figuring that the temperature which the beer will have when it enters the cooler will be 6° higher than the cooling water at disposal. Divide the result by 1,000. This will give the number of tons of refrigeration required per brew.

If you have a beer cooler 24 feet long you can cool with it 100 barrels per hour, and with a 20-foot cooler, 80 barrels. Divide the number of tons above obtained by the number of hours required to cool your daily brew, and multiply the result by 24, to get the capacity of the machine needed for beer cooling only, machines being estimated on 24 hours' work. Add this amount to the amount required for the cellars. This will give the total capacity of the machine required, provided a direct expansion cooler is to be used.

If the machine is on hand and a new one cannot be placed, the beer cooling can be done by brine, and the work of cooling the beer distributed over 24 hours. In that case, the machine need only be large enough to do the actual work of beer cooling in addition to cellar cooling. But this is very expensive, as explained before, first, in running expenses, and secondly, in first cost, as the brine tank has to be very large in order to store sufficient brine for the work.

Since the brine cannot well give off more than 12° and do *efficient work, each* pound of brine will furnish only 10 heat-

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units, the specific heat of brine being 0.8. One ton of refrigeration being = 284,000 heat-units, we must store 28,400 pounds of brine for every ton of work required for the beer cooling, which amount takes up a space of 400 cubic feet.

If, for instance, we have to cool 400 barrels of beer 40° in four hours, we would require 16 tons of refrigeration in four hours. The capacity of a machine to do this in a day would be 16 tons a day, or two-thirds of a ton per hour. We can, therefore, do directly only $4 \times 0.66 = 2.64$ tons, and must store the rest of 13.36 tons, which would require a tank of 5,344 cubic feet, or measuring about $24' \times 20' \times 12'$, an enormous tank.

AMOUNT OF REFRIGERATION REQUIRED FOR CELLARS.

Many sources of heat which have to be removed must be considered in this calculation, viz.:

1. The heat transmitted through the walls;
2. The heat given off by the first fermentation;
3. The heat given off by the second fermentation;
4. The heat given off by the light used;
5. The heat given off by people working therein;
6. The heat admitted by opening the doors.

It would be too complicated to go into details regarding items 4 and 5, and therefore only general data are given for these items.

Heat produced by one man per hour, 518 th. u.

Heat produced by one candle per hour, 430 th. u.

Heat produced by one gas flame burning 3.5 feet per minute, 3.650 th. u.

HEAT TRANSMITTED BY WALLS.

We have to consider each side, the ceiling, and floor separately, if the temperature on the other side of them is different from that inside the room.

Ascertain the number of square feet of sides, ceiling and floor, and their respective temperatures outside, taking, of course, maximum temperatures; for instance, for the shady side, 90°, for the sunny side 110°, for not cooled sides adjoining living or storerooms, 75°. Use the values for each case as given below.

The heat transmitted per square foot, per day and per degree difference between the temperature inside and outside of the wall in question, is as follows:

For rooms containing 2,000 cubic feet and over, when insulation is superior, 2½ th. u.

When insulation is good, 3 th. u.

When insulation is not very good, as thick brick walls not insulated or having no air spaces, 3½ th. u.

For rooms containing under 2,000 cubic feet, 4 th. u.

For rooms containing under 1,000 cubic feet, 5 th. u.

For rooms containing under 600 cubic feet, 6 th. u.

For rooms containing under 300 cubic feet, 7 th. u.

The differences in the above figures are caused by the influence of opening the doors, which will have almost the same effect for small as for large rooms, but is greater proportionally to the whole in small rooms than in large ones.

The side which is most exposed to the wind should be considered 50 per cent more difficult to cool, therefore, if the value for it is 4, it should be changed to 6 in this case.

For instance, we have a cellar, the insulation of which is called good, the weather side is one of the long sides, and the side opposite it is the sunny side; one of the short sides adjoins a room used for general cold storage, and the other short side adjoins a cooled room, the temperature of which is 40°; the ceiling is the floor of a cooled room, which has a temperature of 34°, and the floor is on the ground, but well insulated, the temperature of the ground being assumed to be 55°. The room in question is to be kept at 34°. Then we have:

Weather side	$40 \times 10 \times 3 \times 1.5 \times$	$(90 - 34) =$	100800 th u.
Sunny side	$40 \times 10 \times 3 \times$	$(110 - 34) =$	91200 th. u.
Cooled side	$20 \times 10 \times 3 \times$	$(40 - 34) =$	3600 th. u.
Storage side	$20 \times 10 \times 3 \times$	$(75 - 34) =$	24600 th. u.
Ceiling	$40 \times 20 \times 3 \times$	$(34 - 34) =$	00000 th. u.
Floor	$40 \times 20 \times 3 \times$	$(65 - 34) =$	74400 th. u.
Total			294600 th. u.

Now, 284000 th. u. represent one ton of refrigeration. If we divide the above number of thermal units by 284000, we have therefore, the number of tons of refrigeration required per day = 1.04 tons.

We must now determine the amount of pipes required per ton of refrigeration, which is 400 feet of two-inch pipe per *ton, when the difference in temperature between gas and air is 22°. For instance*, the suction pressure is 27 pounds; then *the temperature* of the gas is 14°. In this case, the temperature

of the air would have been $14 + 22 = 36°$. If the difference is only one-half, we shall need only one-half of the amount of piping, = 200 feet, and so on.

HEAT FROM FERMENTATION, WARM KEGS, ETC.

To this amount must be added the following amount of piping to take care of the first and second heat of fermentation, cellar washing, and warm kegs.

Add for each barrel of daily brew:

In fermenting room........................7.4 feet of 2" pipe
In ruh cellar................................2.2 feet of 2" pipe
In chip cellar...............................1.6 feet of 2" pipe
In racking room, kegs not previously cooled..4.0 feet of 2" pipe
Racking room, kegs previously cooled........1.2 feet of 2" pipe
In keg room, for each quarter entering, not
considering the daily brew...............1.0 feet of 2" pipe
In hop rooms................................0.0 feet of 2" pipe

if the room in question was a fermenting room and belonged to a brewery producing 100 barrels per day. If more than one room of any kind is to be cooled, the above rule of adding pipes applies only to that portion of the daily brew this cellar takes care of. We would accordingly require, in our examples, 720 feet outside the 400 feet required by the cellar itself to absorb the heat transmitted through the walls, which was one ton. Assuming a difference of temperature between gas and air of 22°, this one ton will require 400 feet of pipe, or the cellar complete, 1,120 feet of two-inch pipe.

AMOUNT OF WORK REQUIRED FOR BEER COOLING.

For all practical purposes the formula as given before will be sufficient, i. e., multiply the number of barrels by the number of degrees you want to take out, and divide by 1,000; the result is the number of tons of refrigeration for a difference of temperature of 28°, which will be obtained when cooling beer to 40° with a suction pressure of 25 pounds. (12°).

The following sizes are recommended, but can be reduced 25 per cent, if absolutely necessary:

To cool beer from 60° to 40° give 12 two-inch pipes.
To cool beer from 70° to 40° give 16 two-inch pipes.
To cool beer from 80° to 40° give 20 two-inch pipes.
To cool beer from 90° to 40° give 24 two-inch pipes.

If the difference in temperatures is not 28°, then the number of pipes should be increased in inverse ratio to the difference in temperatures between 28 and the new difference.

THE STEAM END OF THE REFRIGERATING MACHINE.

There are really only two kinds of engines in use connected with refrigerating machines, viz., the slide-valve engine, either with throttling governor or with cut-off governor, and the automatic cut-off engine with Corliss valve and cut-off (for both of which see under the head of "Steam Engine").

Slide-valve engines are used only for smaller machines, where the parts of the Corliss motion would be too small to work well or for machines where cheapness is the first consideration.

There is another occasion where it is advisable to use a slide-valve engine, even for larger size machines and where the matter of first cost is not the principal consideration; that is in the case of an ice plant where no additional exhaust steam is on hand to make up the shortage of distilled water, which will occur when Corliss cut-off is used. Here it is immaterial whether the extra amount of live steam used to make up the required amount of distilled water has been taken directly from the boiler, or has gone through the steam cylinder and is condensed as additional exhaust. In other words, the economical use of the steam need not be considered. It is advisable to use a slide-valve engine in this case, because it is a cheaper engine and furnishes an absolutely tight valve, which cannot be the case in a Corliss engine.

INSULATION.

The object of insulation is to prevent heat passing through walls that are exposed to different temperatures on opposite sides.

There are two kinds of insulation to be considered, which answer quite different requirements: First, the insulation for surfaces where heat is trying to escape, and, secondly, where "cold" is trying to escape, as, for instance, steam pipes for the first and brine pipes for the second.

In the first case, we have only to provide an insulation of sufficient thickness and non-conductive quality to retard the passage of the heat as much as possible, which cannot, of course, be done with absolute perfection.

In the second case, the insulation must be such that the temperature on the warmer side must never be so low that the atmospheric air, coming in contact with it, will reach its dew point, that is to say, be cooled so much as to condense some of the moisture which it carries, as this would cause sweating of the insulation, and spoiling it, and cause dripping, which is disagreeable and often injurious.

If it is remembered that in surfaces which are cooled on one side the difference of temperature is seldom more than $90° - 12° = 78°$, whereas, in steam pipes, for instance, it is generally $340° - 90° = 250°$, it is readily understood that thickness is not so important for insulation for cold surfaces as for the protection of warm surfaces.

In protecting cold surfaces, the principal consideration is to have air and water-tight material for the insulation. The influence of the thickness of insulation for protecting cold surfaces is also important, but what will happen if air, and with it moisture, penetrates the insulation?

First of all, the moisture will condense on the colder part of the insulation and on the surface to be protected, and will be frozen, finally destroying the insulation and, perhaps, the surface in a short time, affording a better escape for the cold, and finally cause dripping. While, therefore, ample insulation is necessary for warm surfaces, it is financial suicide to employ anything but the best insulation for cold surfaces, because it is not only the loss in cooling power which we suffer, but also the cost of a frequent renewal of the insulation.

WALL INSULATION.

Since one can hardly expect to get an insulation absolutely tight, it should be of such a nature as not to be spoiled in case moisture should enter together with air. It follows that all such material as mineral wool, felt, cork, charcoal, etc., which, if it should get moist, becomes a good conductor of heat, should be avoided, as there is no other remedy than to tear down the insulation if once spoiled.

On the other hand, confined air is one of the best non-conductors, and certainly it is the cheapest possible material.

Now, it might be claimed that in order to have good, tight air spaces, the material and labor would cost more than where granite, wool or cork is used. But this is a mistake. N

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matter what we use to fill the spaces with, the spaces themselves must be so made that they are air and water-tight, whether filled with air or any other substance. Hence, confined air affords the cheapest and best insulation which can be had, and is the only insulation which can be dried out, when once spoiled, by simply blowing hot air into the space.

Relative Value of Non-conductors.

(Chas. E. Emery.)

Non-Conductor.	Value	Non-Conductor.	Value.
Wood Felt	1.000	Loam, dry and open	0.550
Mineral Wool No. 2	0.832	Slacked Lime	0.480
Mineral Wool with tar	0.715	Gas House Carbon	0.470
Sawdust	0.680	Asbestos	0.363
Mineral Wool No. 1	0.676	Coal Ashes	0.345
Charcoal	0.632	Coke, in lumps	0.277
Pine Wood, across fiber	0.553	Air Space, undivided	0.136

With all possible care it will still be difficult to make the partitions forming the air spaces absolutely tight, and this is just as impossible as when any other filling is used. But we have some substances which will do what we require of a perfect insulation, viz., pitch or resin, or any other substance of a like nature which is not too expensive, is impervious to air and moisture, will not rot, and is a first-class non-conductor. In this case, it is not necessary to have the partitions air-tight, except the one which the warm air strikes, and this only to protect it from getting moist, if the layer of pitch is not thick enough to prevent a sufficient reduction of temperature on the exposed side, which might cause condensation. If the pitch is thick enough, even this partition can be made simply to hold the pitch in place.

The refuse pitch in breweries, mixed with some resin to give it the right consistency, makes an excellent insulation.

Hollow Tile.—From the above it will be seen how wrong it is to use hollow tiles when air spaces for insulation are wanted, unless they are carefully glazed all over, and the joints perfectly made with the best cement. But how can this be done on the inside unless they are laid against a surface with cement? It is impossible to make a perfect joint when the hollow bricks *being placed two* inches from the wall, form an air *space, as the mason* cannot be sure that the joint below on the in-

ner side is properly made, and the work cannot be supervised, unless an inspector is on the ground all the time, which is impractical.

If, however, the two-inch space between the tiles and brick wall is filled with pitch and the exposed side of the tiles carefully glazed and well pointed with cement, we have besides the pitch a fairly good air space, and can call the insulation first-class. See Fig. 1. A good plaster on the exposed side of the tiles will be better still, as it forms a uniform surface. and there is no dependence on the work of the mason to make the joints perfect. If the tiles have not been carefully jointed, the amount of pitch required is astonishing, as the pitch will run into the hollow tiles, which, of course, improves this insulation, but is expensive.

Fig. 1

Hollow tile wall.

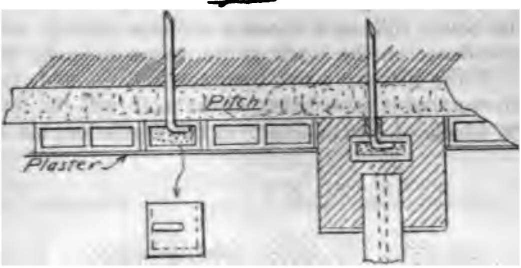
The inner wall, built of tiles, must be tied to the main wall, which can be done, as shown in Fig. 1, by building in hollow tile binders at intervals, which will be filled with pitch, being in connection with the two-inch pitch space; another method is to provide at intervals special tiles with openings for iron hooks, which have been masoned in previously, in the main wall, the holes in the tiles being arranged so that the tile can be slipped over the hook. The pitch will then enter the hole and fill this tile, which should be closed at the bottom to prevent waste of pitch. The hook should be a little longer than necessary, so that the space between the nose of the hook and the tile can be grouted with cement, to get a solid connection.

The beams should rest on pilasters, built inside the pitch space, so that they cannot transmit heat, being comparatively *good conductors. If thought* necessary, these pilasters may *be tied to the main wall*, as shown in Figs. 1 or 2.

There are other forms of insulation:

1. *Two-inch pitch between the main wall and a retaining wall* on the other side of the pitch, the retaining wall held in position by iron hooks masoned into both walls, and the beams passing through the retaining wall into the main wall. This has two serious disadvantages. The iron hooks and the beams will be

Fig. 2

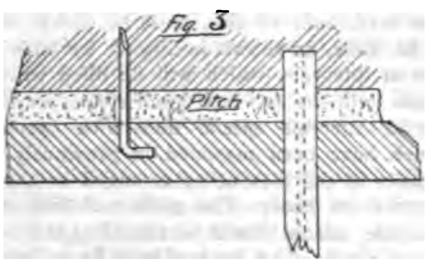


Hollow tile wall.

Air space formed by tiles.

very good conductors, and both pass through the pitch, breaking the insulation there. Fig. 3.

2. *The same insulation having pitch between the main wall* and retaining wall: hooks to secure the inner wall to the outer, but the beams resting on pilasters built into the retaining wall

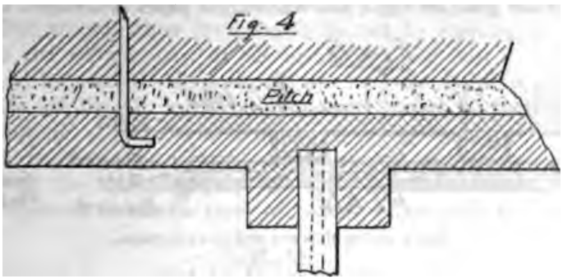


Two-inch pitch space, beams passing through pitch.

so as to prevent the beams from passing through the pitch. Fig. 4.

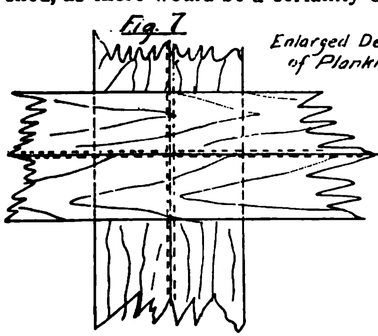
3. *Insulation of a brick wall with wood, using pitch to fill space between* boards and wall. Studs are secured to the wall *by wall hooks,* to which either one layer or two layers of tongue

and grooved paper is nailed as tight as possible, to prevent the pitch from running out. It is not advisable to place the studs too far apart, as otherwise the filling-in of the pitch would have to be done very slowly, to prevent bulging out of the

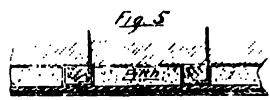


Two-inch pitch space, beams resting on pilasters inside.

boards. Eighteen to 24 inches is the best for the purpose. If it is immaterial how the inside of the wall looks after the pitch is filled in, one layer of boards will do. If not, it might be best to put the second layer of boards on after the pitch is hardened, as there would be a certainty of getting a clean inside wall.



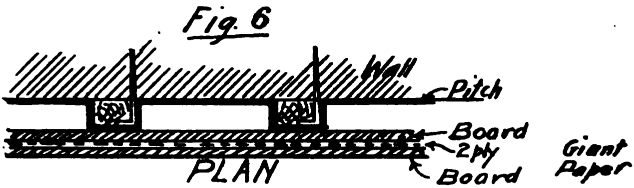
Brick wall with wood and one air space.



Brick wall with wood and one air space.

4. *Insulation of a brick wall with wood and one air space.*—Fig. 5. Place studs against the wall, about 36 inches apart, and fasten them to the wall with wall hooks. Coat the wall and studs with a good layer of pitch and tar mixed, so that there is absolutely no leakage of air or moisture possible through it. Nail one-*inch matched boarding* horizontally against the studs, taking

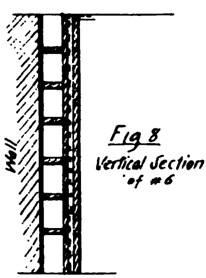
care to have them tight against each other. Nail two-ply insulating paper of a superior quality against the boards, the joints well overlapping, as well as the corners, and make all joints with good paint. See, also, that there are no holes in the paper. Only when good air-tight and water-tight paper is clamped tightly



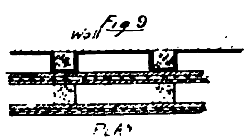
Brick wall with wood and one air space.

between two boards can a reasonably tight air space be expected. Against this paper nail another layer of ⅞-inch matched finished boards, also horizontally, breaking joints. Fig. 6. This is done because when boards are laid crosswise, and they shrink, openings will be formed where the joints cross, and the paper will be exposed and not properly clamped. Fig. 7.

There is now an air-tight space as good as we can make. But the air in this space is not yet still or confined air, which is required for a good non-conductor It can be made so



Preventing air circulation.



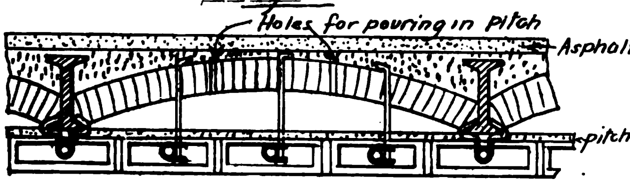
Brick wall with wood and two air spaces.

by putting cross partitions in the space, made of rough boards of any thickness, and which need not be fitted very accurately, though it will be better if they are reasonably tight. These *cross boards should* be provided at least every 18 inches, better *every 12 inches*, and need only be spiked to the studs. These

cross boards will prevent any circulation of the air in the air space, as this air circulation would increase with the height of it, which is mostly 10 feet, on the principle of a chimney, only, in this case, the circulation of the air is caused by the cooling of the air at the top by the cooling pipes located there, which cooled air will then drop, being heated by coming in contact with the warmer part of the insulation, and thus a circulation would be started. This should not be. By dividing the whole height of the air space into as many spaces as possible, this circulation is reduced to a minimum. Fig. 8.

5. *Insulation of a brick wall with wood and two air spaces.*—Against the insulation just before described, again lace uprights, and against these one layer of boards, paper, and boards in the

Fig. 10



Figs. 10-14—Iron Beams and Concrete or Brick Arches.
False ceiling.

same manner, the air space to be four inches for the first, as well as for the second space. This insulation can be called first class. Fig. 9.

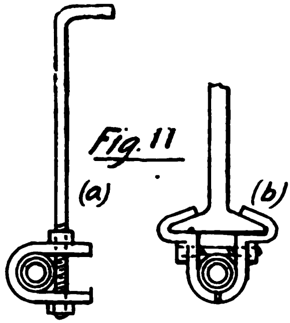
FLOOR INSULATION.

1. *Iron Beams and Concrete or Brick Arches.*—Fill the space over the arches with a mixture of cinders and cement, up to a little above the level of the beams, say, one inch above, and put two inches of good asphalt on top of it. The arches below must be protected, also, and especially the iron beams, as they will transmit cold freely and will sweat.

An expensive way, but undoubtedly the best, is to suspend a false ceiling below the arches by hangers and bearing bars of iron, the false ceiling itself consisting of hollow bricks filled with pitch. This gives a first-class air space between arches and false ceiling, and an almost perfect pitch space in and above the hollow tiles. The pitch should not only fill the tiles, but cover

them. The flooding with pitch can be done from above before the asphalt and filling is put on, and filling holes can be left for putting in the pitch, which can afterwards be cemented over. Figs. 10, 11a, 11b, 12, 13.

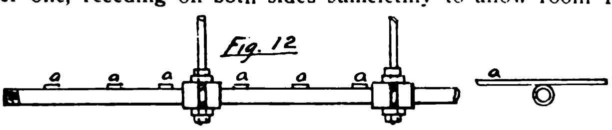
As shown in Fig. 11a, hangers are masoned in the arches, and in Fig. 11b hangers are fastened to the beams at such distance



Figs. 10-14—Iron Beams and Concrete or Brick Arches.
Fastening the hangers.

from each other that each length of pipe, which may be one inch diameter, will carry the tile for its whole length without sagging too much, being supported at one end by the socket into which it is screwed, which again is held by the hanger. The socket must be so much wider than the hanger that it can be taken hold of with a pair of pipe tongs.

The upper side of the tiles near a hanger is shorter than the lower one, receding on both sides sufficietnly to allow room for

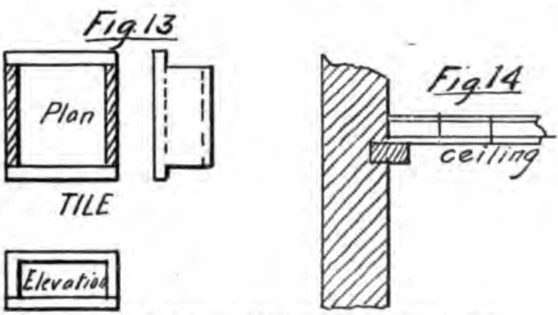


Figs. 10-14—Iron Beams and Concrete or Brick Arches.

hanger and socket, while the lower side is full size, so as to form a tight ceiling. The tiles should be carefully joined, and pointed with cement, so that the pitch, which is afterwards poured in, will not leak through.

The pipes acting as bearing bars are provided with light pieces of band iron screwed to them for holding the tiles in

a horizontal position. It will be seen that the tiles belonging to one bearing bar can be slipped over it before the final hanger is adjusted, and if the bearing bar is not made too long, and will not sag too much by the weight of the tiles, the hanger can easily be slipped on, and a little sagging adjusted by screwing up the nut in hanger Fig. 10, and tightening the bolt in Fig. 11b, since, in the latter case, the ends lapping over the beams must of necessity be made tapering to accommodate the shape of the flanges of the beam. When the last tile has been slipped on the respective bearing bar and the hanger adjusted, the socket, which is right and left, connects the two adjoining bars.



Figs. 10-14—Iron Beams and Concrete or Brick Arches.

The last bearing bar.

The last bearing bar, near the opposite side of the room where the laying of tiles was commenced, must be shorter by just the width of one tile, so that the tiles can be slipped on and a little bracket formed underneath by leaving a course of bricks or tiles out of the wall and putting it in when the last tile has been put in place. Fig. 14.

When the whole false ceiling is completed the pitch is poured into the openings provided in the arches until it safely covers the top of the tiles. No iron will then penetrate the ceiling, which is absolutely air-tight. The holes for filling are closed with cement, the filling put on the arch, and the asphalt floor made.

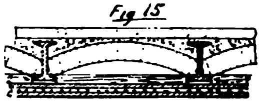
2. *Iron Beams and Arches, Insulation of Wood Below the Ceiling.*—The arches are again covered with cinders mixed

with cement, till the beams are covered, and a two-inch asphalt floor laid on top. Then pieces of wood are wedged in between the beams for which the corner of the arch must be cut out a little. The pieces can be inserted easily and made tight by putting them in at an angle, then turning them till they are vertical to the beams. They should be fitted tight, and hammered into place, so as to form a secure basis for nailing the boards to it.

Then rough one-inch matched boarding, paper, and again finished matched boards are fastened to it, as described for the single air space insulation for the sides. This will form one good air space, and can be improved by adding another, say, two-inch, air space to it, as in the double air space for insulation of sides. Fig. 15.

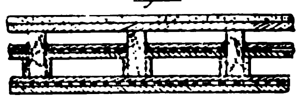
The ceiling thus formed should be varnished, to preserve it.

Fig 15



Insulation of wood below the ceiling.

Fig 16



Wooden beams and wood floor above.

3. *Wooden Beams and Wood Floor Above.*—The floor should be laid last. The beams should be provided with cleats (Fig. 16), to support the false ceiling in the middle, which consists of rough matched board, paper, and rough matched board, secured to the cleats and laid in the same careful manner, as described in the side insulation, and the paper turned over at the corners. Then a heavy floor should be laid and either calked or covered with a layer of asphalt, which adds to the insulation. Below there should again be nailed rough board, paper, and finished boards, in the usual careful manner. This will furnish two good air spaces.

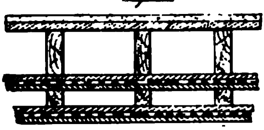
Should the floor be already made, and it be desired to insulate it well, then a second layer like the first one should be added below, with, say, two-inch spacing pieces between the two floors. Fig. 17.

4. *Floor When on the Ground.*—A solid foundation is the *first thing to be secured.* If the ground is clay or solid ground, *a thin layer of concrete* should be provided, according to the

weight the floor has to carry. Then a layer of cinders, mixed with cement, as much as six inches, and, finally, a layer of asphalt, not under three inches, as the two lower layers do not afford much protection against the penetration of heat from the ground and the asphalt has to do nearly all the work.

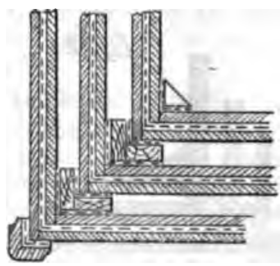
The ground perhaps has only 65°. Yet having an inexhaustible supply of heat at this temperature, and being in close contact with the floor, good protection should be afforded the floor in order to get good results in cooling the cellar. This is why the old style of underground cellars has been abandoned. Formerly, when temperatures of only 45° were had, and especially where the ground was cooler, as in the East, where the

Fig. 17



To insulate a floor already laid.

Fig. 18



Side corner of ice box.

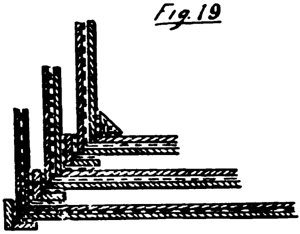
temperature of the ground is usually 56°, or in Germany, where the temperature is still lower, it was advisable to build cellars underground. But not so at present.

Where there is loose ground, and it is not desired to build a heavy concrete foundation, wooden sleepers can be laid, and heavy flooring on top of them, then an air space or two, formed, as described before, by two layers of board and one of paper. The only danger in that case is that the wood may rot from below, and it should, therefore, be at least well impregnated, or, better still, the sleepers should rest on piers made of brick or cement, girders being laid upon them, on which finally the sleepers rest, and the space below should be well ventilated, to *prevent dampness from* accumulating. Good drainage must *also be provided.*

ICE BOXES.

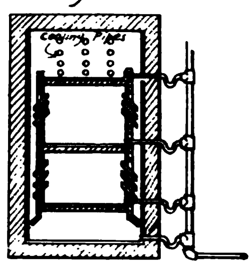
In building ice boxes, the same principles hold good as for cellars, with the exception that we have no walls to insulate, but must form them. The box should consist of three partitions, formed of two layers of board and one layer of paper, as described before, only that in order to save space, thinner wood can be used, and the air space reduced to two inches or less, if absolutely necessary. However, the wider the air space, up to four inches, the better the protection. Care must be taken, though, to build the box so that every part of it is actually protected by two air spaces, that the paper is overlapping well on joints and corners and all laps made with suitable paint. Especial care must be given to the doors. They should be well fitting and have good fasteners. It must also be borne in mind

Fig. 19



Top and bottom corner of ice box.

Fig. 20



General arrangement of ice box.

that the doors should not be too large, and as many compartments as possible be provided, because the opening of a door admits a large amount of warm air each time, the amount being greater in proportion to the increased size of the door and the compartment.

Floor and ceiling should be just as well protected as the sides, the box lined with galvanized iron, and properly drained.

A stationary box can be made very well with pitch insulation by making a single layer of boards on the inside, which, when lined with tin or galvanized iron, is sufficiently tight, and one layer of boards tightly fitted on the outside, which, after filling with pitch, is covered with a second layer of finished matched boards and varnished. The pitch should then be at least three inches thick. If the box must be moved at times, the pitch might

crack by the box being slightly changed in shape, and in that case it is better to employ air spaces. But no other material should be put in the air spaces.

An ice box with compartments is best built with a pipe chamber on top, the floor of which is made of wood, covered with galvanized iron, to prevent dripping, and well drained toward a pipe leading out of the box, forming a gooseneck, so as to allow the water to get out, but keeping in the cold air.

From this coil box two flues, extending the whole width of the box, should lead down to the top of the lowest compartment, conveying the cold air to each compartment, the inflow to be regulated by shutters. This will give the desired temperature for each compartment, which can be kept at different temperatures, if desired.

Ceiling and underside of shelves should not be lined to prevent dripping, but varnished.

Fig. 18 represents a side corner, Fig. 19 a top and bottom corner, and Fig. 20 a general arrangement of ice box, with several compartments and coil chamber.

FREEZING TANKS AND BRINE TANKS.

The sides should be insulated with an air space next to the tank, to prevent the pitch coming in contact with the very cold sides of the tank, and to afford a chance for the escape of brine if any should be spilled or leak from the tank. Over this air space should be constructed a pitch space, and again an air space on the outside. It must be understood that since very low temperature prevails in the tank, better insulation is needed than for walls of rooms. Instead of the pitch a second air space can be substituted, making in all three air spaces, the iron of the tank, which should be well painted, forming one side of the inner air space.

The covers, loose ones as well as tight, should be formed of three layers of board, with two layers of paper between.

The bottom insulation should be made like the floor of insulated buildings erected on the ground, only an air space being, perhaps, added to provide for the lower temperature of the brine. The tank should be set on one-inch wooden strips and undercast with pitch. This will bed the tank well, prevent rusting of the bottom, and lead off, by means of a drain pipe with gooseneck, all brine which accidentally or by leakage collects upon same.

INSULATION OF PARTITION WALLS IN CELLARS

If both adjoining cellars have nearly the same temperature, any kind of material will do, and no insulation is necessary, but when on one side of them is a warm room or stairway, the same care must be taken to insulate them as the outer walls. Under no circumstances should hollow bricks only be used, and if the difference in temperature is not very great, they can be filled with pitch, and will then be fairly well protected.

Under no circumstances should sawdust be put on a floor above a cooled room, as is frequently done. The moisture of the atmosphere will penetrate it, and when the moisture strikes that part of the sawdust which has the temperature which is the dew point of the air, it will condense, make the sawdust moist, and convert it into a good conductor, besides spoiling the floor. This can be easily proven by examining such layer of sawdust, which has been used for a summer, at the end of the season, when the weather is still hot. The sawdust will in such case be found very wet.

INSULATION OF COLD PIPES.

The same considerations prevail here as in the protection of cold surfaces. But care should be taken never to cover the pipes when they are cold or sweating, as this will spoil the insulation right at the start.

Any kind of insulating material can be used, for instance, felt, magnesia, or paper cells, anything, in fact, which is a non-conductor, as air spaces cannot well be built around the pipes, and it is therefore just as cheap to use a filling material. The chief consideration here is again that the insulation is air and water-tight on the outside. Covering the material with good canvas well sewed on and coated with three coats of good elastic paint, will make the insulation air and water-tight. Especial care should be taken to get tight finish for the ends. It is likely that a puncture of the canvas will occur, which would spoil the whole insulation under the same cover. It is therefore better not to take the insulating material very thick, but to make two, or still better, three distinct air and water-proof insulations, one over the other. If the first one is punctured and spoiled, *the rest* remain intact, and no harm is done, while the punctured *layer still affords* a little protection, although less than one not *punctured.*

The pipes should first be well painted. A tar paint is best for this purpose, if the smell while putting it on is not objectionable. Then a layer of felt or any other good non-conductor should be wrapped tight around the pipes and tied with wire. Copper wire is considered best for this purpose. Over this, a layer of good insulating paper, as tar paper, which is pliable, is laid, and then the whole coated with one or two coats of good elastic paint. Then again felt or other insulating material is wrapped tight with copper wire, still another layer of tar paper, and the latter coated with paint as before. It is best to tie the tar paper also, as it will give a more compact insulation, not so easily destroyed by knocking against it. If it is not thought necessary to add another layer of felt and tar paper, the canvas should be put on tight and well painted, as explained.

Another form of insulation, and the best where it can be used again, is made with pitch. The pipes are layed in boxes upon rests giving at least a three-inch space from outside of pipe to inside of box. The box is closed tight with a lid, and pitch poured in. This insulation can easily be removed by opening the box and knocking or melting out the pitch, and when the pipe is repaired, closing the box and putting in hot pitch, which will join the new and the old insulation. This process can be assisted by slightly warming the box on the outside where the insulation is to be joined.

If pipes are laid under ground, the box should either be made of cast-iron or impregnated wood, and the wood should be at least two inches thick. Clay pipes can also be used to lay the pipes in.

If the pipes are above ground, galvanized pipes made of thin iron can be used and the cold pipes held in place therein by wooden, or any better, insulating material which can be found, as a spacer. Pitch is then poured in through openings left for this purpose. The single lengths of pipes are joined by soldering, and special form pieces made for fittings. This insulation can also be easily removed and repaired, and is the very best, preserving at the same time the cold pipes and saving their paint.

IRREGULAR BODIES, AS PUMP CYLINDERS WITH CHAMBERS.

The best method is to use material which can be applied in a *plastic state, in* sufficient thickness, and then to protect

the outside of the parts in question as thoroughly as possible by painting or by putting on air-tight plaster or placing canvas over it and painting well, always bearing in mind that the outside must be air and water-tight.

WATER COOLING TOWERS OR GRADIR WORKS.

Where water is required for ammonia or steam condensers, and the well supply is insufficient, or where it is too expensive to use city water, the only help is to erect a water cooling tower.

The only natural cooling agents are water and air. To use air directly for condensing purposes would need too cumbersome an apparatus, and be too expensive in first cost. But we can cool the water first with air, and do it cheaply and efficiently, the water in this case not being wasted, but used as a medium to carry the heat of condensation to the air.

The principle of the cooling tower is to allow air and water to come into close contact and to exchange heat thereby, and, further, to evaporate a small part of the water, the air absorbing the moisture, and the heat necessary to evaporate this part of the water being abstracted from the remaining water, cooling it in this manner lower than the air could do by contact alone.

That part of the water which is evaporated must be replaced. But since this is only from 5 to 10 per cent, according to the temperature of the water entering the cooling tower and the capacity of the air for taking up moisture, the amount required is small, and if the well does not furnish it, can be bought from the city, and yet considerable money saved by the erection of a gradir works.

CONSTRUCTION OF COOLING TOWERS.

The construction of the cooling towers varies. That cooling tower is the best which will give the best chance for evaporating water. This can only be done if the water is retarded as much as possible in its downward course and not mixed with the air, but the air allowed to pass over the surface of the water only. For steam-condensing purposes this evaporation is not so important, as the temperatures of the cooling water required for this purpose need not be so low as for condensing ammonia, where a difference of a few degrees in the cooling water cuts a big hole in the coal pile.

The general construction of cooling towers is a cylindrical or square enclosure, made of wood or iron, containing means to distribute the water and to retard it in its downward course, and a large fan for blowing air in the opposite direction over the water. A good cooling tower is made of a square box of white pine, well painted on the inside, and filled with one-inch boards of cypress, arranged far enough apart to allow free passage of the air. On top are placed iron gutters which receive the water and distribute it through pipes to the gutters provided for each portion. In order to retard the water as much as possible, the second row of partitions is arranged perpendicularly to the upper one, and so on, each row being again provided with gutters so as to distribute the water well.

In this manner the water will always run in a thin film over the partitions and have the best chance to evaporate. This crossing of the partitions has another advantage, viz., that it forms square openings for the air to pass, and spreads the air, supplying each particle of water with air.

The fan is placed in an extension built to the structure at the bottom.

Another kind of cooling tower is made, where either galvanized iron tubes of short length and about four inches diameter are placed in the cylinder forming the tower, so as to break joints, or pipes made of clay of about the same dimensions as the iron pipes are used. The latter will last longer than the iron pipes, but are considerably more expensive and heavier, which is a consideration when the cooling tower is placed on the roof.

Some builders put wire screens in the structure, which will soon rust out and make the water unfit for boiler feeding.

All these towers use fans. But there are some made which are open all around and utilize the natural draft of the air, instead of a fan.

The towers which employ tubes or wire screens, with sprinkling devices instead of gutters, cannot be expected to furnish such low temperatures as towers with vertical partitions and gutters, since in the first case the water and air is thoroughly mixed and little chance for evaporation given, while in the second case all facilities for evaporation are afforded.

COST OF COOLING TOWERS.

A 100-ton refrigerating machine would require a cooling tower of 200 × 1440 = 288,000 gallons per day, which requires a fan of nine feet diameter, making 190 revolutions, and requiring 12 horse-power to drive it.

The cost, complete, will be in the neighborhood of $2,000. It will require, if used for cooling water for ammonia condensers, about 5 per cent of 288,000 gallons a day, to make up for evaporation = 14,400 gallons. The 12 horse-power, if a small engine for driving the fan is used, costs about 72 pounds of coal per hour, and if the tower is erected on the roof, so that the water runs by gravity to the ammonia condensers, the pumping will not cost more than to pump the water from the well, as the extra height the water is to be pumped is more than made up by the depth from which the water is generally pumped if taken from a well.

These figures will suffice to calculate whether it pays to buy a cooling tower or not.

The life of the cooling tower must also be considered when figuring on the investment. Iron towers with galvanized iron tubes cannot last long. The tower cannot be repainted on the inside without great cost and without ruining the tubes. It will, therefore, rust through quickly, as will also the tubes. On the other hand, wood, especially cypress, will last for a long time.

The tower can be erected on the ground instead of on the roof. But in that case the ammonia condenser floor must be located high enough to allow the water to flow to the gradir work by gravity. A height of about 35 feet is required for this purpose, otherwise the water must be pumped twice.

PUMPS.

CENTRIFUGAL PUMPS.

These pumps are used when large quantities of water are to be lifted to moderate height, that is to say, not to exceed 28 feet. They are cheap pumps, but must be run very fast.

A pump of this kind, delivering 200 gallons to a height of 50 feet, makes 1,200 revolutions per minute, and a pump of the same capacity, lifting the water 30 feet, makes 1,000 revolutions. *They require for this* 4.25 horse-power and 2.55 horse-power, *respectively. A pump lifting* 1,000 gallons 50 feet makes 920 *revolutions and requires* 25 horse-power.

ROTARY PUMPS.

These pumps have two interlocking wheels, one of which has a projection engaging the other, which has a recess to suit, and thus discharging what has been in the recess of the one wheel.

These pumps should be run slowly, to make them last long and to prevent noise. Fifty revolutions is a good speed for them, but they can be run up to 200 revolutions. They are cheap pumps, are driven by a belt, and are made in capacities of 8 to 25 gallons, which capacity they have when making 50 revolutions, or, they will discharge 30 and 90 gallons per minute, respectively, when running at their maximum speed of 200 revolutions. They will lift water very little; it is best to have the water flow to them. They will discharge water 12 to 15 feet high. The pumps are very cheap, and where power to drive them can be had easily, they are preferable.

POHLE AIR LIFT PUMP.

This apparatus consists of an air compressor, an air tank, and an air discharge pipe, located either inside the water discharge pipe, which also must be provided, or between water discharge pipe and well casing. The water discharge pipe and the air pipe should reach down the well casing so far that the length under water is twice the length of the water discharge pipe over the water in the well, that is to say, if it is desired to lift water 66 feet above the level of the water in the well, the two pipes must reach at least to 132 feet below the level.

The principle of this apparatus is that there must be such pressure carried in the air tank that the column of water pressing against the orifice of the water discharge pipe, in this instance 132 feet high, will more than counterbalance it, otherwise the air would escape without doing work. The pressure, therefore, must be not quite 65 pounds, as 65 pounds' pressure is about equivalent to the pressure exerted by a column of water 132 feet high. If compressed air is discharged into the orifice of the water discharge pipe 132 feet under the level of the water in the well, this air mixes with the water and forms a column of a mixture of both air and water, which is 198 feet high, which mixture will reach the upper outlet of the water discharge pipe and will *flow out.*

The air in the water will escape and the water be discharged in short intervals, and not as a steady stream, but sufficiently so for all practical purposes. It is better, however, to provide a water discharge tank holding a good supply, so that any interruption in the working of the apparatus will not stop the water supply for the brewery.

Where the conditions are favorable to the employment of this kind of apparatus it should be used, as it is economical. No pump rods and working barrel are buried in the well, in fact, all parts which must be attended to are above ground. It has been found in several cases that wells which furnished plenty of water, but could not be pumped sufficiently with a deep-well pump, after being worked with the air lift, furnished twice the amount of water that they did before.

Where foul or thick water is to be pumped and more than 28 feet lifting done, this system is advisable. An air compressor is provided, located on the ground, and two large tanks placed so that the fluid will fill them by gravity. The tanks are provided with floats, actuating a valve motion, which opens or cuts off the air supply, and check valves are secured to the tanks to admit the water when it has been forced out of the tank and the latter connected at the top with the outside, to let the compressed air out, which still fills the tank.

While one tank is filling, the other is discharging. In this manner the fluid does not come in contact with any delicate machinery, and cannot injure it, whatever the nature of the fluid may be. Furthermore, by this process, the fluid can be lifted to any desired height, while the machinery is located above ground and easily accessible. This apparatus is used in mines, but can also be used to empty cisterns or cesspools, and can be started and stopped automatically.

PLUNGER PUMPS.

This is the simplest kind of pump made, having the least number of valves and parts, and being very easy to keep in order. These pumps are generally used where the clearance is no object, for pumping liquids. It can also be constructed to have only an equal clearance to a piston pump, but in this case a piston pump is preferred, because it is just the construction made regardless of clearance that makes the pump so simple, as the valve chamber is screwed to the pump cylin-

der, and each valve is in a separate casing, covered with a lid which can be removed by loosening one bolt.

These pumps are used where high pressures are wanted, but if constructed with clearance, should not be called upon to lift the water, as this would be unsatisfactory, owing to the large clearance. This pump will also move heavy liquids better than a piston pump.

MEMBRANE PUMPS.

If heavy liquids are to be pumped in smaller quantities, or the liquids contain acids which should not come in contact with iron or brass, the compressed air system would not be suitable, and membrane pumps are a very good means to accomplish what is wanted.

The pump consists of two parts, a plunger pump charged only once with water, which water presses a diaphragm against one and the other inside surface of a lens-shaped vessel. The diaphragm is clamped between the two halves of the lens-shaped vessel, the water being on the one side and the fluid on the other side of the diaphragm. The fluid follows the motions of the water, which is withdrawn and discharged alternately into this vessel by the motion of the plunger pump.

The vessel is provided on the fluid side with a discharge and suction valve, which admit and discharge the fluid alternately.

This apparatus is cheap and gives good results. The rubber diaphragm requires replacing from time to time.

DEEP WELL PUMP.

These pumps are mostly built as plunger pumps. Since it is necessary to place the working barrel far below the surface, such submerged parts should be made just as simple as possible. The plunger is connected to the steam cylinder, which is erected above ground, by long piston rods, making the whole system very cumbersome and getting out of repair frequently. If the working barrel is very deep in the well it is not easy for the engineer to repair it. If the conditions required for an air-lift pump do not obtain, there is no other way than to use a deep-well pump. These pumps can discharge water to any reasonable height.

PISTON PUMPS.

These pumps are now universally used. They are double-acting and built as single and duplex pumps. In some cases even triplex pumps are made, mostly in case of power pumps provided with gears. The valve chamber in these pumps is generally located on top of the respective cylinder, and the valves therein placed in two stories, the suction valves below and the discharge valves above. This arrangement enables the engineer to take out the discharge valves first, and, through their seats, the suction valves, which are made a little smaller, to allow their passing through the seats of the upper valves. This also makes it possible to use many small valves and avoid the noise big valves would make when seating.

The water piston is generally connected directly to the steam piston by the same piston rod, which is called a direct-acting pump. The steam valve, usually a piston valve, is connected to the pump piston rod by a suitable lever motion, to allow the steam to enter and to leave the steam cylinder at the proper time. This arrangement makes the stroke of the pump variable, as the adjustment of the valve lever motion determines this stroke, and though ever so nicely adjusted, the stroke varies almost with every revolution. This reduces the capacity of the water cylinder and, still more, the efficiency of the steam cylinder, as the increased clearance wastes much live steam. That is why such pumps, especially when small, possess such low efficiency, using about 120 pounds of steam per horse-power per hour, while a small Corliss engine produces the horse-power with 40 pounds of steam, if attached to the pump with flywheel. If that is done, the stroke will be positively equal for every revolution, and the smallest possible clearance can be given to the water and the steam cylinder.

The direct-acting pump has, however, many advantages, which often more than counteract the loss in efficiency, viz., smaller first cost, simpler construction, making it possible for a laborer to handle it, and the possibility of regulating the revolutions at will.

If, instead of the Corliss engine, a slide-valve engine is connected with a pump and a flywheel added, the economy will be greater than if directly connected, and yet the pump is not much more expensive nor the handling and regulating more difficult.

Larger pumps are often built with Corliss compound and condensing engines, and instead of the flywheel, an air balance is used, insuring full stroke. There is economy in the use of this pump though it is very expensive.

ARRANGEMENT AND CONNECTION OF PUMPS.

The most economic and best way, if it can be done, is to collect all the pumps into a room near the engine house and to give the engineer sole charge over them, all pumps to be belt driven and connected by belt to countershafts.

Such countershafts should consist of two long, conical drums, placed close together, one of them sliding with its bearings in the frame holding both drums, and pressed against the other by strong springs or weighted levers, with an endless belt between them. This belt hangs loosely around the lower pulley and can be shifted by a shifter from one end of the conical pulleys to the other. This belt makes the connection between the two conical pulleys and connects at one end, the point of the driven conical pulley with the butt end of the conical pulley to be driven, thus giving a large change of speed to the pulley to be driven. The driven conical pulley is keyed to the same shaft with a pulley connected by belt to the main countershaft, and the conical pulley to be driven is keyed on the same shaft with a pulley which is connected with the pulley on the pump.

All the speeds which are possible with a direct-acting pump can be had with this countershaft, and if the engineer is connected by electric signals with the man requiring the use of the pump, he can regulate the speed to suit all purposes, stopping and starting the same at a moment's notice, if a signal for preparation has been given and the engineer has answered. Such an arrangement would allow the use of a large compound condensing Corliss engine, which would utilize the steam with the greatest economy, save many repairs and time of the engineer attending to pumps, while the life of the pumps would be at least twice as long as otherwise.

Another important circumstance is the annoyance of having to lead steam pipes a long way, especially through cooled cellars. Water pumps, particularly, which have their supply near the engine room, are cheaper to connect, as instead of a steam

an exhaust and a suction pipe, only one discharge pipe is needed.

If the pump is needed close to the place where the pumping is done, an electric pump, or a pump driven by compressed air, should be used, the air compressor being located in the pump room, and only one compressed air pipe leading to the pump from the pump house. This will give an advantage over steam pipes, because the air is not hot and cannot lose energy like the steam, by condensing in the long pipes, and furnishing wet steam.

Pumps for brine and water should be brass lined and fitted.

COMPRESSED AIR PUMPS.

These must be flywheel pumps, as the clearance in the air cylinder must be reduced to a minimum to get good efficiency from it. The air compressor must have a water jacket to remove the heat of compression, and internal water injection is often resorted to for cooling the compressor still more effectively.

If it is desired to cool the air still further, this can be done by sending it through a pipe cooler, over which either water of ordinary temperature is showered, or, the cooler can be built like a Baudelot cooler, and water circulated over it, the same water to be used over and over again. If still lower temperatures are required, brine can be used as the circulating medium instead of water.

The air pump must be provided with a pressure regulator which keeps the pressure at the desired figure, independent of how much air is used.

COMPRESSING AIR BY USING WASTE WATER.

In a brewery which has a refrigerating machine, there are generally large quantities of clean water running away from the ammonia condensers, which water generally has a fall of 35 feet, and can be used to compress air without the use of a pump.

If, for instance, a 100-ton machine is on hand, it uses 200 gallons a minute, and the water falling 35 feet, represents power to the amount of nearly two horse-power. Two air-tight tanks are provided and fitted with safety valves, to be set at the pres-

sure required—which cannot be more than about 15 pounds when the fall is 35 feet—and two floats are so connected inside the tank with valves that they allow the flow of the water when required, and, when filled, open the water outlet and an air inlet at the top. While one tank is filling and compressing the air, the other is emptying out the water and filling itself with fresh air, and is ready as soon as the first tank has discharged all its compressed air, to supply compressed air also. The air must be discharged into a receiver to collect any water which may have been carried with it, and to equalize the pressure. This tank should also have a safety valve attached. Such apparatus would furnish about 26 cubic feet per minute of 15 pounds' pressure, without any cost for power. If the water is clean, there can be no objection to using the air for racking beer. Another advantage is that this air will have the temperature of the water, coming in close contact with same.

STEAM EJECTOR.

This is a very useful and cheap instrument, and easily connected, where it can be used. It will heat the ejected water somewhat, since the steam must condense to do the work. The lifting of the water is done by the vacuum created by the condensation of the steam.

To take water out of a tank or cistern, it is very handy. It will lift small quantities 20 feet high, but should not be expected to work against pressure. It is especially adapted to cases where a means of lifting water must be had quickly and where ordinarily such apparatus is not required.

STEAM JET PUMP.

This pump is very handy and cheap, and also easily connected. It will start with 10 pounds' steam pressure, and will lift water 10 feet high with a steam pressure of 80 pounds. It will discharge the water 40 feet high.

BREWERY BUILDINGS.

Following is given sample specifications for a medium-sized brewery, abridged from a set drawn up by a brewery architect of note. It is intended only as a sample, to afford a general idea of the requirements as well as to call attention to details that might otherwise be neglected. What suits one locality may not suit another. There are considerations of size and shape of lot, magnitude of the plant, building materials, labor, climate, etc., which will necessarily modify plans in each individual case.

Specifications are always made out with reference to plans drawn. Where the words "as shown" occur in the following, it is intended to convey the need of referring the contractor to such plans:

EXCAVATION, FILLING, CONCRETE WORK, MASONRY AND BRICKWORK.

Excavate ground according to plans and sections, dig trenches for footings of all walls, piers, etc.

After foundations are in, refill, ram heavily and puddle with water all filled-in material. Ground floor must be left in proper shape to receive the floor. Fill up where necessary and leave the ground for fifteen feet all around the buildings in proper shape, slanting easily. All superfluous ground to be carted away.

All foundations must be started on natural ground. The foundations for all walls, piers under columns, etc. (concrete foundations), shall be made of concrete up to Datum or o-line, and of sizes as shown by drawings.

CONCRETE.

All materials used for concrete must be measured by struck bushels, or barrels, and not by shovel.

Concrete to be prepared in the following manner: One part of imported German Portland cement (Dyckerhoff, Germania or

Stettin) must be mixed in a box, first, dry, with 2½ parts of sharp and clean sand; then water to be added, just enough to make the mortar resemble damp earth, and well mixed. Then five parts of broken stone to be added, and mixed again. Stones must not be larger than to pass a 1¾-inch netting. Mortar must fill out all empty spaces between broken stones. Lay the concrete in six-inch layers, ram heavily with a heavy ram. A film of thin mortar must cover the stones after ramming.

For concrete foundations above natural ground construct heavy boxes to receive the concrete and give foundation proper shape. The concrete work must be carefully protected against the influence of the weather. The top of concrete must be leveled off with Portland cement mortar, mixed in proportion of one to two and one-half.

For all sewer and other pipes required contractor must leave openings in concrete or brickwork, and cover same with 12 inch thick stones or arch them over.

DIMENSION STONES.

Dimension stones must be laid on top of concrete and solidly in a floating bed of cement mortar. Top and bottom of dimension stones must be practically smooth, and be rammed down with a heavy wooden instrument. The lower courses of dimension stones under columns may be in two pieces each, but the balance of courses to be of one piece each and of even thickness. The stone under foot-plate must be well bush-hammered, to give the plate a solid bed. Dimension stones under walls must measure the entire spread of foundation in one direction, in the other not less than three feet. All the spaces between dimension stones must be well filled with concrete.

RUBBLE STONE WALLS.

Rubble stone walls are to be started on top of concrete work. Stones must be laid in courses of even size and not less than 8 inches thick. The first course lying on concrete must consist of stones going all through walls in one piece, and this must be repeated in the fourth course, that is to say, one course of dimension rubble alternating with three courses of common rubble work.

Walls must be well bonded and joints carefully broken. Far *walls on both sides,* and wherever they come in contact wi

ground, plaster them with cement mortar specified for concrete. All exposed rubble stone must be range work made of select rubble laid in regular courses. Where stone walls show above ground they must be neatly pointed up with mortar.

Mortar for rubble stone work, except for pointing and plastering, to be composed of one part of imported German Portland cement and two and one-half parts of sharp and clean sand. Contractor to furnish sample of stone.

BRICKWORK.

The footings on top of concrete must be of best hard burned brick in level courses. The brick must be laid wet if laid in warm or dry weather, and dry, if laid in cold or damp weather, with absolutely solid joints, leaving no empty spaces in wall whatever. This may be accomplished by grouting every course, or by doing shove work; the outside of the work being laid all headers and no course projecting more than about 1⅜ inches to 1½ inches beyond the one above it, except for piers, under columns, etc., where the projection will be ¾ inch to 1 inch.

Base plates must be blocked up at the corners to proper height, then close up the sides with clay, and fill the joint with German Portland cement mortar, mixed one to two and one-half. Foundation walls above footings to have a header course every fifth course.

Mortar for brick footings and foundation walls up to eighteen inches above ground line to be made of one part of Louisville cement to three parts of clean, sharp sand, both to be measured by struck bushels or barrels, and thoroughly mixed dry before adding water.

Brickwork above foundation walls to be built. Mortar to be made of nine bushels of good, strong lime to one yard of clean, sharp sand. To fifteen parts of this mortar add one part of Louisville cement. Brick discharging arches to be built over all openings where no iron lintels are used.

Where firewalls are built above the roof, lay two-inch by four-inch pieces in walls, so that bottom of piece will be three inches above roof boards. This to be omitted where wall above roof exceeds a height of ten feet.

All joists or wall plates must be set on walls without blocking, even if brick have to be split for the purpose. All wall

plates to be set and no walling up of beams to be done before anchors are in right place, according to iron diagram.

Brickwork around columns in walls to be anchored to columns with ⅛-inch copper wire.

Brickwork for Smokestack. The inner shell must be well tied to outer one, every four feet in height up to where the round part starts. After that the shell must be tied where rings are placed. Inside of chimney must be lined with firebrick for a height of twenty feet, starting the firebrick eighteen inches below the bottom of smoke opening.

Floors to be arched between the steel beams with four-inch brick arches laid in Portland cement mortar. Build up stag walls in haunches of arches eight feet apart and nine inches wide to top of beams and across level with top of arch, forming beads, so as to prevent beam from giving, or being pulled out of plumb when strain is put on tie rods. Arches to be leveled off to top of beams with concrete made of sifted cinders and German Portland cement, mixed one to six. Soffits of all arches must be neatly pointed up, except those over fermenting and settling tub room, which will be plastered.

All enclosing walls of *stockhouse* in all stories, excepting the rice storage and ventilation floor above settling tub room, the racking room and hop-storage room, to be furred or lined with an eight-inch brick wall, put 1¼-inch from the main wall. The space between main wall and furring wall to be poured full with hot pitch. Care must be taken that when pouring pitch into that space the brick lining will not bend out or cave. For this reason only eighteen inches of lining is to be built at one time and then the space is to be filled as stated.

Brick layer to wall in the galvanized iron strips which hold the lining. Strips to be two inches wide of No. 16 galvanized iron, reaching eight inches into main wall and four inches into lining, and long enough that they can be bent up two inches at each end. In the horizontal direction strips must be two inches, and in the vertical direction eighteen inches, apart, placed staggering in wall.

Hollow tiling the walls of the above-mentioned rooms. The walls to be painted one good coat of melted asphalt and pitch, and then lined with one row of three-inch hollow tiles; then leav a space of two inches and put on another row of three-inch h

low tiles. Space between the two rows of tiles to be filled with mineral wool (or other insulating material). Hollow tiles used must be good, hard burnt, of uniform color. Each tile must be clamped to the adjoining by galvanized iron clamps (No. 20 iron), and the tile row next to wall to be fastened to wall by spikes in every second course. The outer row of tiles must be clamped to the inner row; clamps to be formed so as to act as separators at the same time. All tile work to be laid in strong approved domestic cement mortar, neatly pointed up, except in fermenting and settling tub rooms, which are to be plastered with one good coat of plaster, composed of four parts lime mortar to one part of imported Portland cement. Cross-walls in settling tub room to be lined only with two-inch mineral wool and four-inch hollow tile and plastered.

IRON AND STEEL WORK.

All castings shall be of tough, gray iron, free from injurious cold shuts or blow-holes. Tops of foot-plates and bottoms of columns must be turned off. Bottom of lowest column must have lugs to correspond with lugs on foot-plates and be firmly bolted to foot-plates. Columns to be straight and sound with all lugs, brackets, caps, moldings, etc., as per drawings.

All wrought iron must be tough, ductile, fibrous, smooth and free from cinder pockets, flaws, buckles, blisters or cracks. All beams must be of steel, straight and of sizes and weights as per corresponding diagram. All work must receive a good coat of mineral paint before delivery.

Holes to be punched in all beams three inches from ends which rest on walls. All splice plates for girders must have four bolt holes, those for floor joists two bolt holes. Stringers, brackets, posts, railings of stairs to be of iron or steel.

Elevator enclosure to be of 5-32-inch wire, 1½-inch mesh, with 1¼-inch channels, or grooved iron for frames, well fastened to walls and guy-post. All doors to swing or to be sliding, constructed strong and similar to enclosure with approved locks. All lintels over openings must have wall anchors.

CARPENTER WORK.

All lumber to be thoroughly seasoned and sound, common pine, free from sap, cracks, loose or large knots or any other

defects that will injure the strength. All lumber must be dressed where exposed to view. All straps, splice plates, anchors, stirrups, etc., for connection of woodwork, also all spikes, nails, bolts, screws, locks and all hardware to be furnished and fitted.

All centers for arches over openings must be set one-half inch higher than frame to take the weight of the wall from frame. Lay two-inch by four-inch scantlings in firewalls only three inches above roof boards for fastening of roofing felt. Build gables behind all ventilators, ventilation pipes, etc., to lead the water to the downspouts. Carpenter to furnish and hang the wooden centers for brick arches between the steel floor beams and remove them after arches are sufficiently dry.

All openings in mason work, if not otherwise specified, must have yellow pine lintels six inches high by the required width, resting on walls at least four inches. All joists from nine feet to twelve feet span must have one row of cross-bridging. Joists from twelve feet to eighteen feet span to have two rows of cross-bridging and above that three rows.

Bridging to be made of good, sound two-inch by four-inch stuff, well fitted at the ends and solidly nailed in place with two ten-penny nails at each end. Where joists are planed, planed bridging is to be used. Frame out for ventilators, ventilation pipes, scuttles, etc., or wherever framing is required. All headers and trimmers must be double, thoroughly spiked together and well framed and hung in extra heavy iron stirrups. Every fifth joist must have strong pin anchors, pin not less than fifteen inches long and straps extending well into wall. Ends of joists must butt against each other over girders and every pair must be spliced by two-inch by twelve-inch by three-eighths-inch wrought iron splice plates with two spike holes for each end of joist.

Floors, ceilings, sheathing of roofs, etc., must be firmly spiked or nailed to each joist or rafter.

Doors and Windows. All window and door frames must be surfaced all around, as they will be primed all around. All door and window frames to be set in place by carpenter. All window frames and sashes must be of thoroughly seasoned pine. All windows must have window stools where practicable. Windows in cold rooms to have triple sashes and plank frames, which must begin four inches or eight *inches from outside of* walls as may be provided, and go all

through walls and hollow tile lining. Sashes to be 1¾-inches thick, made to swing as shown on drawing. Center sashes must be arranged for double glazing. All joints between window frames and walls must be caulked with mineral wool (or other insulating material), and made as air-tight as possible, and then strips nailed over joists. All other windows to have box frames and 1¾-inch sashes with check-lipped meeting rails.

Mullion windows to have molded mullion posts, transom bars, transom sashes, etc. Heads of all circular, semi-circular or segment windows, to be square inside. Transoms to be semi-circular or segment all through walls. Sashes to be hung with weights and best braided cotton cords, and to have extra strong axle pulleys and extra strong sash locks and lifters.

All outside doors to be 2¼ inches thick, made in two thicknesses, well glued and screwed together, paneled, upper panels arranged for glass. Door frames must be 2¾ inches thick, starting four inches back of face of wall, paneled and molded to correspond with doors, all with transom bars, mullion posts, transom sashes, etc., complete. Each wing of the doors must be hung to three extra strong wrought iron, black japanned five-inch by five-inch loose joint butts. Doors must have extra strong three-tumbler mortise locks top and bottom bolts, etc., complete. Transom sashes to be of same thickness as doors below and hung with strong black japanned wrought iron hinges and have the required transom lifters of the strongest make.

All thick or insulated doors must be made as follows: Seven-eighths-inch by 3½-inch matched and dressed flooring, double building paper, ⅞-inch flooring, 1½-inch by 1½-inch strips, sixteen-inch centers, then ⅞-inch matched flooring, double building paper, and ⅞-inch matched flooring, all solidly nailed together. Doors to be hung to extra heavy black japanned ice-house T-hinges and have proper locks. Insulated doors must have groove cut all around and a rubber tube fastened into it to keep the space between doors, frame and floor tight. Door frames for all insulated doors must be 2¾ inches thick and reach all through wall and hollow tile lining where not otherwise specified.

All doors not before specified, in refrigerator, boiler and wash-house, must be made in two thicknesses of ⅞-inch by 3½-inch matched flooring with double layer building paper between and stiles and rail complete. Doors to be hung to 4¼-inch by 4¼-

inch black japanned loose joint butts and have all required locks, etc. All doors in brew-house, not specified before, must be 1¾ inches thick, five panel O. G. hung to three 4¼-inch by 4¼-inch black japanned loose joint butts, and have strong mortise locks, etc.

Sliding doors to be made of two thicknesses of 1⅛ inches for stiles with ⅞-inch by 3½-inch matched and beaded floorings for panels.

The doors of stock-house, wash-house and brew-house, having iron jamb protectors two feet six inches high, to be made so that frame will be flush with protector when in place. Frames to be screwed to protector with stove-bolts before being set. Doors in stock-house to be made as specified for insulated doors, slide or swing. When sliding they should be hung with weights to wire and running over heavy steel anti-friction pulley, polished brass wheel, heavy strap hinges to be used for insulated doors and the same to be bolted to doors. Oak sills to be five inches and full width of wall with 1½-inch projection and properly washed and seated.

Coal shutters in boiler house must be of two thicknesses ⅞-inch by 3½-inch flooring, with two-ply building paper between and have proper stiles and rails. The box window frame in boiler house must be made large enough to receive the coal shutters, which must be hung in same manner as sashes in the same frame; the coal shutters to slide in iron jamb protectors between the two sills which are to be of four-inch oak. All doors must have oak thresholds. All stiles and rails of doors and shutters to be of thoroughly seasoned pine, panels of well seasoned pine.

Scantling in hollow tile partitions for fastening of door frames must go up to ceiling.

BREW-HOUSE.

Tower of brew-house to be constructed as shown on plans. Wall plates will be six inches by eight inches, well anchored to walls with ¾-inch diameter anchors.

Build two trusses for tower, made of double two-inch by twelve-inch truss rafters, and double two-inch by ten-inch cords, well spiked together. Intermediate rafters will be two inches by eight inches—sixteen-inch centers. Frame out for the windows and build roofs over same as shown. The other part of roof over brew

house to be constructed of three-inch by ten-inch sized and planed joists, planed eighteen inches on centers. Cross-bridging to be as specified before. Joists to rest four inches on walls and give same proper pitch for gravel roof. Roof over brew-house, including tower, to be sheathed with one-inch by five-inch matched and dressed flooring, dressed side laid down.

Build a two-foot by two-foot six-inch scuttle on one side with light, but strong scuttle cover and hung on strong wrought iron japanned hinges, and have all necessary fastenings complete; also provide neat, light and strong ladder to scuttle.

Mash-tub platform must be made of three-inch by six-inch dressed and matched flooring, planed to be turned down and well bolted to top flange of ten-inch steel beams with ⅝-inch bolts.

Build Malt Bin As Shown. Support for hopper bottom of malt bin to be constructed of ten-inch by ten-inch timbers for girders and posts. Joists for bottom to be three inches by twelve inches on centers, and sheathed with three-inch by six-inch matched and dressed flooring. All woodwork must be solidly and completely framed together with all necessary irons. Bin walls to be made of crib-work, constructed of two-inch by four-inch scantlings, surfaced on all sides, well spiked together with 4½-inch and four-inch wire spikes mixed, put in zigzag, sixteen inches apart. All crossings must be spiked with 4½-inch spikes. Bin rods and ladder irons will be furnished by another contractor, but must be put in place by carpenter. Spout openings in bottom of bins must be made in the most careful manner. Cover of bin must be made of two-inch by six-inch planed joists, placed eighteen inches on center, and nailed underneath with ⅞-inch matched and both sides dressed flooring. The lumber used for construction of bins must be thoroughly seasoned and dry hemlock, and without any bad knots and other defects. Bin partitions must be perfectly plumb out and inside. Provide a trap door to each bin in floor of tower where shown with strong hinges and connect to wooden shaft going down into bins. Stairs will have iron stringers and railings furnished and put in place by another contractor, but carpenter must construct platform and furnish and solidly screw to iron brackets on stringers 1¾-inch sound white oak treads. Platforms must be made in strongest manner of three-inch by six-inch planed joists securely fastened to iron stringers and covered with two-inch by four-inch matched white

oak flooring dressed on both sides. All required hardware to make the carpenter work complete must be furnished and put in place. Carpenter must build partition for office and closet and also brewmaster's office of two-inch by four-inch studs, sixteen-inch center, sheathed on brew-house side with ⅞-inch matched flooring. Put shelves and ceiling into closet. Around Baudelot cooler, both sides to be finished with neat cornice panels, mouldings, etc., plain but tasty. Baudelot cooler partition to have sliding sashes below and above platform. Doors to be sash doors. Posts, stiles, panels, rails, moldings, etc., of partitions to be of the best quality yellow pine.

Hardware. All required hardware to be imitation bronze (or as selected). After the cooler is erected, build platform, using four-inch by six-inch joists, planed four sides and floored with two-inch by eight-inch planks, planed four sides and laid with one-inch space between them.

Rice Tub Platform. Build steps and platform for rice tub, as will be directed or as shown.

Floor in office to be made of four-inch by four-inch sleepers, two-foot centers, sheathed with one-inch matched hemlock, then double tar paper and ⅞-inch matched maple flooring.

Ventilator over brew house to be built as shown on drawings in strongest manner of two-inch by four-inch studs spiked to roof joists and double two-inch by four-inch plate below the two-inch by four-inch ventilator rafters. Ceiling joists to be two inches by six inches. Rafters to be covered in same manner as roof joists. Ventilator to be sheathed out and inside with one-inch by six-inch matched and dressed flooring and have windows as shown.

REFRIGERATOR OR STOCKHOUSE.

Girder supporting part of stockhouse roof to be ten-inch by twelve-inch, Georgia pine planed with anchor and fastened to columns with heavy lag screws. Roof joists to be three inches by twelve inches, planed and sized, placed eighteen inches on centers and two-inch by four-inch planed cross-bridging. Roof joists to be sheathed with one-inch by six-inch matched and dressed flooring, dressed side down. Provide five wooden stoppers for three-inch hose thimbles. Provide boxes of two-inch planed stuff, eight inches by eight inches in clear through walls of fermenting room, as shown, to let out the carbonic acid gas. Tight slide

for same. Furnish and put in treads and platform for stairs from fermenting to settling tub room, as described for brew house. Build two scuttles two feet by two feet six inches, one in roof over ventilating floor of settling tubs, and one in lower roof over rice storage room with light, but strong, covers, hung on strong wrought iron hinges, and have all necessary fastenings complete.

BOILER HOUSE.

Build ventilator over boiler house as shown on drawings, in the strongest manner. Bottom plate to be of double two-inch by four-inch, screwed to beams with ⅝-inch bolts. Studs to be two inches by four inches, with double two-inch by four-inch plate below. The two-inch by four-inch ventilator rafter braces to be two inches by four inches, ceiling joists to be two inches by six inches. Rafters to be covered in the same manner as roof joists over brew house. Ventilator to be sheathed out and inside with one-inch by six-inch matched and dressed flooring and have windows as shown. Ventilator will be sheathed with iron outside and inside.

MACHINE HOUSE.

Roof joists to be supported by two trusses. For sizes of timbers, etc., see drawings. All timber must be perfectly sound, thoroughly seasoned Georgia pine, free from loose and large knots, cracks or other defects that will injure their strength. The necessary iron rods, washers, etc., will be furnished by another contractor. Spikes and nails to be furnished by carpenter. The trusses must be put together in the most careful and substantial manner and properly put in place. Bolt a three-inch by eight-inch dressed timber to members of trusses, as shown, to support roof joists. Bolts to be furnished by carpenter. Roof joists to be two inches by eight inches placed eighteen inches on centers. Ceiling joists to be two inches by six inches, eighteen inches on centers. Form a truss between roof and ceiling joists of one-inch by four-inch stuff, as shown, every third joist. Studs for ventilator above trusses to be two inches by four inches, with double two-inch by four-inch plate below the two-inch by four-inch ventilator rafters. Braces to be two inches by four inches. Ceiling joists two inches by six inches.

Rafters of ventilator, as well as roof joists, to be covered in same manner as roof joists over brew house. The in and outside

of ventilator, as well as exposed parts of trusses and the ceiling joists, to be sheathed with one-inch by six-inch matched and dressed flooring. Ventilator to have windows, as shown. Stairs to wash house to be made in same manner as brew house stairs.

WASH HOUSE.

Girders supporting roof joists to be twelve inches by fourteen inches, planed, and to be connected with straps, as shown, where they butt against each other above column. Roof joists to be three inches by twelve inches, planed, placed eighteen inches on centers. Sheathing to be one-inch by six-inch matched and dressed flooring.

Shipping platform to be built along brew house, as shown on drawing, in the strongest manner. Brackets to be constructed of eight-inch by eight-inch and four-inch by eight-inch pieces, resting on projecting stones and firmly anchored to walls. Joists to be three inches by eight inches, floored with Georgia pine planks three inches thick and spaced ¾-inch apart. Build stairs on both sides of platform, as shown.

Stock house partition between racking room and chip-cask cellar, to be made of two-inch by four-inch studs, placed eighteen inches on centers, flatways and sheathed on both sides with ⅞-inch No. 1 common matched and dressed flooring. Provide two doors in partition made of double ⅞-inch matched and dressed stuff, put together with double tarred paper between flooring, hung to 2¼-inch frame, with proper butts and trimmed with suitable strong latch and pull.

PAINTING.

The contractor for painting and glazing must provide and use all the necessary materials of every description, including glass, lead, oil, putty, varnish, sandpaper, ladders, scaffolding, ropes and all other things necessary for the performance of the work and do the same in a substantial and workmanlike manner. All materials used must be of the best quality for their respective places. Clean off all woodwork before painting. Sandpaper smooth, prepare all parts properly before painting the second coat.

All knots, sap spots and other defects in woodwork must be *covered with a strong* coat of shellac before getting the first

coat. All planed inside and outside woodwork, including frames, which must be primed on all sides, all doors, sashes must receive two good coats of hard oil finish. Tin roof, gutters, down-spouts and flashing must be given two coats, the first coat to be of mineral paint and to be put on after it has rained on the roof. Colors to be as directed by the owners.

Painter must read over galvanized iron and carpenter specifications to see what work to include, and these specifications are to be considered a part of the specifications for painting.

GLASS AND GLAZING.

Furnish and put in place all required glass. Glass to be No. AA, double thick American glass, well bedded in putty, sprigged and puttied up. All glass must be left clean and whole on completion of the job.

ROOFING.

Cover the roof boards with four-ply and one dry thickness of roofing felt in the following manner: Felt to be evenly and smoothly laid and cemented between each sheet the full width of lap with best roofing asphalt, mopped solid and covered with clean screened gravel, well embedded, not less than ¾-inch thick.

Roof must be guaranteed for five years and all defects arising from poor workmanship or materials corrected without charge or delay. On some of the buildings roofs will have to be cut in many places to allow ventilation pipes, etc., to be put in place, and contractor must make all necessary repairs for this purpose without charging anything extra for it.

HOLLOW TILE.

All the tile used must be good, hard-burned, hollow tiles of uniform color. They must be laid in good, sound bond, and the hollow spaces of tiles must be vertical. Each tile must be clamped to its neighbor by galvanized iron clamps, and the row next to wall to be fastened to wall by spikes in every second course. The outer row of tiles must be clamped to the nearer row, and clamps must be so formed as to also act as separators.

All the tile walls must be laid in strong, domestic cement mortar and be neatly pointed up in rooms which will not be plastered. In fermenting and settling tub room tiles will be plastered and

must have rough surface, all others to have smooth surface, but contractor to confer about this with owners.

Chip-cask cellar, racking room, stock cellar, fermenting cellar: Double three-inch tile, two-inch air space. Settling tub room and hop storage: Triple three-inch tile, double two-inch air space. Mill partition: Single six-inch tile. The roof over boiler house will be covered with three-inch book tile between T-irons in same mortar as specified before. T-irons will be furnished and laid by another contractor.

Tiles which are not plastered on the exposed side should be glazed. Air spaces should be filled with pitch.

Separate bid to be given on filling the air space with insulating material selected.

TINNING, GALVANIZED AND CORRUGATED IRON WORK.

All the tin used to be Caramet brand, ten ounces to the square foot, well painted on underside before laying. All flashing to be done against walls, ventilators, pipes, etc., in the most careful manner, so that roofs be absolutely watertight. Where down-spouts empty on lower roofs thirty-inch by thirty-inch striker plates must be placed on roof and the pieces must have elbows on lower end. All down-spouts must be made of No. 24 corrugated galvanized iron. Where down-spouts connect to sewer extra heavy cast-iron pipes are to be used for the last ten feet. They must be well secured to, but not against, the walls, and be properly calked into sewer.

Tin off roofs of ventilators over ice machine house, brew house and boiler house. The mullion posts and sills to be covered with galvanized iron No. 22. Moldings to be of galvanized iron No. 24. All surfaces to be covered with corrugated galvanized iron No. 22. Cover the inside of boiler house ventilator with corrugated galvanized iron No. 22. Provide neat galvanized iron cornice above windows and neat moldings around ventilator opening. Cover the pendant roof over shipping platform with corrugated galvanized iron No. 16. The tower roof and dormer windows must be covered with best black slate.

Two ventilation pipes of No. 16 galvanized iron for stock house, *sixteen inches'* diameter each, with two cast-iron doors and *cast-iron frames,* doors eight inches by eight inches in each

cellar, as shown. Two-inch by three-inch angle iron collar on pipe in each floor and on roof. Two ventilation pipes for hop room and ventilation floor to be twenty-four inches' diameter, made of No. 16 galvanized iron. All these pipes to have damper on ends and ventilator heads. Furnish and use the necessary guy ropes for same. Three ventilation pipes for top floor of stock house, as per diagram. Three scuttles, each two feet by two feet six inches, two in stock house, one in tower.

Two six-inch down-spouts for brew house, two six-inch diameter down-spouts for wash house, two six-inch diameter down-spouts for machine house, one six-inch diameter down-spout for boiler house, two six-inch diameter down-spouts for stock house and one five-inch diameter down-spout for stock house. Every down-spout to have ten-inch by ten-inch wall box through thirteen-inch wall with conductor head, overflow, etc., complete.

Sheath outside of malt bin with corrugated galvanized iron No. 22, galvanized iron to extend to walls. Galvanized iron must be tightly fastened to brick walls. Trapdoors above bins must be tinned.

PLUMBING.

All soil pipes must be four inches' diameter, extra heavy cast-iron tarred pipe, well coated on both sides and of the best quality, with all proper fittings. All pipes must be put up in the best and strongest manner with iron hooks and stays, set up plumb and true, and the joints calked with oakum and melted lead. All necessary elbows, Y-branches, etc., must be furnished and used.

All cesspools must be constructed so as to secure water-tight connections with floors.

All connections to sewer must be made with metal, well caulked with oakum and asphaltum or pitch. The soil pipes must have proper connections to cesspools and reach proper distance above roof. Above roof, starting at bottom of roof joists, the four-inch pipe must be increased to six-inch pipes. All soil pipes in brew house must have Y-branches eighteen inches under each floor they pass for the reception of overflows and wastes from brewery utensils. Required are the following soil pipes:

Brew House.—Two stacks of four-inch pipes, extending from sewer up through roof.

Stock House.—Three stacks of four-inch soil pipes, extending from sewer up through roof.

Wash House.—One stack of four-inch soil pipes, extending from sewer up through roof.

Machine House.—One stack of four-inch soil pipes, extending from sewer up through roof.

CESSPOOLS.

Required are the following cesspools:

Brew House.—Platform elevator pit, one (1) cesspool, nine inches by nine inches, with bell trap.

First floor, two cesspools, nine inches by nine inches, with bell traps.

Second floor, two cesspools, nine inches by nine inches, with bell traps.

Mash tub platform, one cesspool, nine inches by nine inches, with bell traps.

Third floor, one cesspool, nine inches by nine inches, with bell traps.

Fourth floor, two cesspools, nine inches by nine inches, with bell traps.

Stock House.—First floor, two cesspools, nine inches by nine inches, with bell traps.

Racking room, one cesspool, thirteen inches by thirteen inches, with bell traps.

Second floor, two cesspools, nine inches by nine inches, with bell traps.

Third floor, two cesspools, nine inches by nine inches, with bell traps.

Fourth floor, three cesspools, nine inches by nine inches, with bell traps.

Wash House.—First floor, two cesspools, thirteen inches by thirteen inches, with bell traps.

Second floor, two cesspools, nine inches by nine inches, with bell traps.

Machine House.—First floor, four cesspools, nine inches by nine inches, with bell traps.

Second floor, two cesspools, nine inches by nine inches, with bell traps.

Boiler House.—Two nine-inch by nine-inch cesspools, with *bell traps.*

CEMENT FLOORS.

All the floors must be given the proper pitch by contractor, all grading or filling which may be necessary to bring the ground to proper grade must be done and the ground must be solidly rammed down to make a solid foundation for the floor. Under the concrete a layer of cinders solidly rammed down must be placed by the contractor in specified thickness.

All traps and cesspools must be set in proper height and place and the floors must be laid even, smooth and without any buckles or hollows and properly pitched toward gutters or cesspools. Around all walls, piers, columns, openings, etc., floor must be turned up at least one inch. Gutters must be properly formed where shown on drawings. The gangways must be high in center and slope to gutter and the edge of gutter toward gangway must be ¾ inch lower than the edge toward casks. Concrete must be prepared in the following manner: One part of imported Portland cement and three parts of sharp and clean sand must be mixed, first dry, then water to be added, just enough to make it resemble damp earth, then add about six parts of broken stone not larger than to pass through a one-inch diameter ring. All must be thoroughly mixed. No ocean sand must be used, sand to be entirely free of salt. Concrete must be well rammed and fill out all spaces between the stones, and a film of thin mortar must cover the stones after ramming. The finishing coat must be made of one part of imported Portland cement and one-half part of clean sharp sand. Where no stone sills are provided, floors must be laid between openings.

The ground floor to receive three inches of cinders, five inches or three inches of concrete and a finishing coat one inch thick. The floors of ventilating lofts above settling tub room and hop storage to be laid with concrete made of sifted cinders and cement in proportion of six parts sifted cinders to one part of imported Portland cement and to be eight inches thick over eye beams.

First floor of stock house to have three inches cinders, five inches concrete and one inch finish. First floor of brew house, ice machine house and boiler house to have three inches cinders, three inches concrete and one inch finish. Ceiling of hop storage room and ceiling of settling tub room to have eight inches cinder concrete. Office floor, three inches cinder and four inches cinder

concrete between four-inch by four-inch sleepers placed two feet on centers.

PLASTERING.

All tile walls and brick ceilings which are to be plastered will receive one coat; plastering must follow the curves of the brick arches. Surface must be rubbed to even surface. All corners and angles must be plumb, square and true.

The mortar used for plastering must be made from one part of imported German Portland cement and four parts of good strong lime mortar. Contractor must find all necessary scaffolding, ladders, etc. Only sweet water sand to be used. All rubbish belonging to plasterer must be removed on completion of job.

Partitions of office and brewmaster's office to be lathed and plastered two coats, one of hair mortar and one finished as above described, and walls and ceilings of these two rooms to be plastered on brickwork.

ASPHALT FLOORS.

Concrete must be well rammed down and mortar must fill all spaces between stones. A film of thin mortar must cover the stones after ramming. Where no stone sills are provided floor must be laid between door-jambs, without extra charge. All cesspools to be set in proper place and made tight. Floors must be even and smooth and have proper pitch to cesspools. Gutters to be properly formed and cesspools to be set in right place.

Floors must be turned up around walls, columns and openings at least one inch. Where the difference in connecting room is not above four inches contractor must provide easy inclines for the doors. Examine building plans and execute in accordance therewith.

Floors, three inches concrete, one inch asphalt. Extra concrete under Baudelot cooler, beer tank and water tank. In mash tub platform, double tar paper, two inches concrete, ¾ inch asphalt.

Wash house floor, three inches cinders, four inches concrete, two inches asphalt. Hop storage, four inches cinder concrete, three inches concrete, one inch asphalt. Floor above, ¾ inch asphalt.

Natural Rock Asphalt.—Asphalt is a natural product, a bituminous limestone in which carbonate of lime and pure mineral bitumen are intimately combined by natural agency, the proportion averaging from six per cent bitumen and 94 per cent car-

bonate of lime to twenty per cent bitumen to eighty per cent carbonate of lime. Bituminous rock asphalt is found in Kentucky, Utah, California, Limmer, near Hanover, Germany, Lobsann, Alsace, Neufchatel, Switzerland and France. Mineral bitumens are found on the British Island of Trinidad, West Indies; Bermudez in Venezuela; Barraquilla in Colombia, Central America. Bitumen, or so-called maltha, is also found very extensively in California.

Bitumen to be good should be free from dross, non-evaporating, and contain no oil that will evaporate at 400 degrees Fahrenheit, and at 70 degrees Fahrenheit have the consistency of beeswax. Refined Trinidad pitch will always contain from 20 to 30 per cent of fine clay, nevertheless it is preferable as a fluxing material for melting natural rock asphalt mastic than some other short-fibered bitumen chemically purer. Bitumen and mineral pitch are interchangeable, but asphalt stands alone.

The largest deposits so far known on the American continent, covering an area of some twelve miles square are situated in the Indian Territory, Arbuckle Mountains, the center of the concession being Brunswick Station, three miles east of Dougherty, Indian Territory, on the Santa Fe Railroad.

FLOORS OF BREWERIES, STABLES, DRIVEWAYS, ETC.

Under usual circumstances, one inch of rock asphalt, laid over a three-inch concrete foundation, will stand ordinary traffic for many years.

For wash houses and racking cellars, a thickness of 1½ inches, laid over a four-inch cement concrete foundation, is advisable.

For residence cellars and floors, for light business purposes, ¾-inch asphalt, laid over three inches of concrete, will make an everlasting floor, and will cost only a trifle more than a floor made of cement.

A square foot of asphalt one inch thick weighs about ten pounds; ¾ inch thick, about 8½ pounds.

Advantages.—The chief good qualities of a first-rate asphalt mastic are its utter imperviousness to water or dampness, and its elasticity, which prevents cracking, especially from the influence of frost. From a sanitary point of view also the advantages of an asphalt pavement are incontestable, for it possesses great antiseptic properties, and owing to its having no joints it is *impossible for particles of* animal or vegetable matter to lodge in

crevices and putrefy. It greatly promotes cleanliness, as it can be easily washed, and for this reason it is invaluable in breweries, hospitals, morgues, slaughter houses, stables, waterclosets, etc.

INSULATING INSIDE WALLS OF COLD STORAGE, STOCK HOUSES, ETC.

The contractor of insulation work will include in his bid the coating, as indicated on plans. For all inside walls the material for this work shall be either Trinidad or bitumen asphalt. This material is to be heated in regular asphalt kettles and applied to the walls while hot. The walls to be cleaned with a steel broom and all loose mortar, etc., to be removed before the coating is put on.

Contractor will not be allowed to carry on this work if walls are wet or damp, which will prevent the asphalt from binding to the walls. Contractor may use in connection with the above material a pure grade of bitumen for fluxing. The mixture should be prepared by competent laborers who have had experience in this line. The contractor shall see that a uniform mixture is kept for the full completion of said work. The coating to be of such consistency that when the temperature of the cellar is about at freezing point or under, the asphalt shall have sufficient elasticity, and that in case a higher temperature is kept up in the different rooms it remains of the same hardness. Nothing but experienced labor will be permitted on this job, and the contractor will be required to furnish evidence of the laborers so employed in this work, of their qualification, and to discharge any such person or laborer from said building if so requested by the owner or superintendent in charge.

MISCELLANEOUS SPECIFICATIONS.

As the specifications for following would be different for the various appliances, etc., to be installed, and as each manufacturer requires different conditions for operating or installing his devices, it is practically impossible to compile a general form of specification. The following items are, therefore, only such as apply generally, and are in nowise complete. For such devices, etc., complete specifications are usually submitted by the different bidders and vary much from each other.

REFRIGERATING MACHINE.

All work called for in these specifications, or that may be necessary to make a complete plant, according to latest practice to refrigerating engineers, whether specified or not, must be furnished by the contractor, and all work and materials must be of the best for the purpose. Contractor must examine building plans and execute all work in accordance therewith. Plans and specifications are intended to co-operate.

MACHINES.

Furnish and erect on the foundations built by the owners, according to plans and template furnished by the contractor, the refrigerating machines required. The machines are to have contract capacity when running at ordinary speed, which in no case must exceed (contractor mention speed) revolutions per minute. Foundation bolts to be furnished by the contractor for this work. State size and style of engine intended to drive the machine, also horse power required for operation of each.

CONDENSERS WITH PAN.

Ammonia condensers must be of the atmospheric style. Condensers must be figured on the basis of one section per twelve tons, each section to consist of twenty-four two-inch pipes, each twenty feet long. Each section to be provided with stop valve on the inlet and outlet. Pan for condensers to be made of ¼-inch steel and twelve inches high and of suitable size. Provide slotted pipe gutters. Pan to have large strainer. Condenser room is located over ice machines.

AMMONIA PIPING.

The following rooms must be cooled by the direct expansion system, and contractor is to furnish and erect all the necessary first-class piping to keep the rooms at a temperature of 32 to 38 degrees Fahrenheit all through the year. Rooms to be cooled are as follows: Chip cask cellar, racking room, stock cellar, fermenting room, settling tub room, hop storage room, ice storage room.

Pipes in fermenting room must all be hung in the aisles and along the walls and none over tubs. Pipes in racking room and hop storage must all be hung along the walls. A wooden gutter, ned with galvanized iron, must be provided under the pipes in p storage.

BAUDELOT COOLER.

The upper part of the cooler will be made by another contractor. The lower, or ammonia, part of cooler must be made by the refrigerating contractor, with necessary fittings for direct expansion. This lower portion must correspond in pattern to the pattern used by the coppersmith. Wort must be cooled from about 75 degrees to 38 degrees Fahrenheit in two hours.

ATTEMPERATORS.

Attemperators of the swivel pattern, made of one turn of two-inch pipe, must be furnished and connected to fermenting tubs, and the swivel joints placed outside the tubs, so that any leakage will not run into the wort. The brine, or sweet water, for all the attemperators to be taken from the attemperating tank furnished by owners. All connections to be made complete, including attemperating pump, rubber hose, valves, piping in tank, etc.

AMMONIA.

Contractor must furnish the ammonia for the first charge of system. Contractor must also furnish all the carpenter work that may be necessary in the erection of this plant, and clean out all rubbish made by him. He must also furnish two sets of foundation drawings and one set of pipe connection drawings. All ammonia and attemperator connections must be made by the contractor, but owners will make all steam and water connections. The temperature of the condensing water must be figured at not less than 75 degrees F. Contractor must state in his proposal the amount of water and coal used daily. Condenser pressure must not exceed 180 pounds, with the expansion pressure at 30 pounds per square inch. Around all moving parts of machines brass rails must be erected. Contractor must guarantee his entire work and material for one year and make good any defects found in that time. After the machines have been tested and performed according to contract they must be neatly painted as may be directed by owners. Contractor must furnish a competent engineer for thirty days at his own expense to run the machines and instruct the man the owner may employ as engineer. He must supply a complete set of wrenches and any other tools that may be of special use.

MACHINERY AND MILLWRIGHT WORK.

All of the machinery furnished to be of the best quality and put up substantially and in workmanlike manner. All of the work done to be of the best workmanship. All the machinery put up to be set in running order without any extra charge, complete in every respect and to be of the best improvements. All imperfect work or materials to be removed. All required timbers for posts, bridge tees, supports for hangers and other machinery to be furnished, as well as all required bolts for proper securing. All lumber to be of planed, clear white pine, dry and free from large knots, holes and windshakes. All pulleys for double belts to be flanged inside. All hangers and bearings to be self-oiling. All shafts to be of turned steel. Pulleys to be turned true, balanced and painted. All hangers to be of extra heavy double braced pattern, fastened with strong bolts and cast-iron washers. All bearings to be babbitted with genuine babbitt metal. All machinery must be guaranteed for one year. State time you will need for setting up above machinery from day you receive the order to commence.

STEAM ENGINE.

Furnish and erect on the foundations built by the owners, according to plans and template furnished by the contractor, the (here specify the size and kind of) engine. Strong driving pulley on side. Foundation bolts must be furnished by contractor. State the size and make of the engine you intend to furnish. Furnish and set in place also one upright steam engine for wash house, and bring this engine in right speed connection with main shaft.

MASH RACK.

Furnish and set in place one right-hand improved hydraulic mash machine, with grains remover and step for bottom and top bearing. The step at bottom to be furnished to the tankmaker, who will put the same in. Deliver and set up one hydraulic pump in connection with rack. The upright shaft to be of steel.

RICE RACK FOR RICE TUB.

Furnish and set up in place one right-hand rice rack, with step for bottom and top bearing. The step at bottom to be furnished to the tankmaker, who will put same in.

MALT MILL WITH REEL.

Furnish and set in place one iron non-explosive malt mill. Furnish on top of mill one reel, complete, as shown on draw-

ings, including driving shaft, bevel wheels and tight and loose pulleys, dust chamber, etc., as usual. Provide magnets above mill to keep iron nails, etc., out.

MALT ELEVATOR.

The elevator legs and head (if of wood) to be made of 1¼-inch finished clear white pine, screwed together, and put in on every joint one iron plate two inches high; make the legs perfectly malt tight.

GRAIN CONVEYOR.

Conveyors must each have one extending shaft with tight and loose pulleys.

SHAFTING.

Shafts, hangers, pulleys, collars, wall boxes, pillow blocks, miter wheels, bevel wheels, friction clutches, etc., to be specified in detail.

SPOUTS.

Provide swivel spout from malt elevator to malt bins and also to the feed hopper above reel and from malt mill to meal scale hopper, and from this hopper to mash tub, made of No. 18 galvanized iron, the latter to be provided with meal-tight slide and operating lever. The spouts from and to meal scale hopper are not to be fastened on to hopper, but made meal-tight by rubber. Provide spout from outside of building with feed hopper on top to malt elevator and make this removable. Provide the spout from grain valve to grain conveyor from galvanized iron. Provide cast-iron outlets for the two malt bins and connect to malt elevator. Have tight slides in these outlets and arrange transmission for opening these slides from the millroom upstairs.

SCALES

For meal hopper will be furnished by another contractor, but unloaded from car, erected and connected complete by millwright.

FINALLY.

All cutting through floors and all walls to be done by the contractor of machinery, and all millwright work. Furnish and put up all necessary posts, timbers, planks, etc., for hangers and supports for conveyors and provide the required belts and stirrups for same, all materials to be of the best quality and first-class workmanship, and the whole machinery to be put up in good run-

ning order before same will be accepted. Provide cast-iron belt thimbles wherever belts pass through floors. The contractor shall be strictly held to do such work and to use such materials as above specified, and in cases where the drawings are figured the figures are to be taken in preference over what the scaling may show. He shall be further held to remove all improper work or materials upon being directed to do so by the superintendent or owner. The superintendent shall be at liberty to make any reasonable amount of alterations in the construction or execution, and will appraise and settle the cost of such increased and diminished work, which will be allowed by the owners or the architects. It is strictly understood that the job must be delivered in running order and everything furnished and used by contractor for this purpose without any extra charge whatever. Owners will furnish the keg scrubber, shaving wash machine and filter mass wash machine, but contractor to submit separate bids on these machines, put up complete with belts, etc., in running order.

COPPERSMITH AND TANK WORK.

All the materials used in the construction and completion of this job must be of first-class quality and all work done in good, substantial and workmanlike manner, and everything to be done and furnished to make a perfect and finished job to the true intent and meaning of drawings and specifications. All the work to be erected complete and in running order in the brew house. All necessary openings to be made in all tanks which may be required for steam, water or other connections, even if not specially mentioned hereafter and flanges of proper size to be furnished and put on. All copper must be of the best Lake Superior quality, well hammered and finished. All brass must be of the best metal and well finished and polished. All steel must be flange steel. All handling, moving and raising of tanks which may be necessary in the execution of other branches of the work to be done by the tankmaker. Contractor must also examine building plans. Give separate prices for each item and state the time it requires for setting up the work complete from date the order for erection is given. Also state the time it takes to get *the materials ready for* setting up from date of the closing of *the contract.*

[redacted]

FOUNDATION WORK FOR MACHINES.

Do all necessary excavating which is required according to plans and refill when foundations are in. Superfluous ground to be distributed on premises. Concrete to be made of one part of Portland cement, three parts of sharp and clean sand, and six parts of broken stone well mixed and rammed. Bricks used in foundations must be extra hard burned brick, laid in Portland cement mortar, composed of one part of Portland cement and three parts of sharp and clean sand. Ice machine bolts and template will be set by another contractor; shafts of bolts must be walled in loose, leaving four-inch by four-inch holes around same, and after machines are set on foundation, all bolt holes must be poured full with clear Portland cement mortar in liquid state.

Foundations for pumps, heater, etc., to be made of brickwork in the same way. All necessary capstones for foundations to be furnished and set. Plans for this work will be furnished by the different contractors.

PIPING.

STEAM PIPES.

Make proper sized connections from steam drum across boilers to engine and ice machine. Run pipe up through brew house, branch off to hot water tank, kettle, mash tub and rice tub, make all connections to pumps and place a valve at each branch. Provide ring around outside of mash tub and make inlets into tub with check valves. On brew kettle two-inch regulating valve, one-inch safety valve, ¾-inch vacuum valve, and a steam gauge. Condensation from brew kettle to go through a steam trap to the receiving tank in boiler house. Make steam connection to copper coil in hot water tank, condensation also to go to receiving tank, but without trap. All the pumps to be set up and connected with the proper size of pipes as required for respective size of pumps and valves to be placed at all pumps. Make also steam pipe connection to suction and discharge of beer pumps for cleaning out purposes. Run steam pipe to wash house. Branch off to keg washer, shaving washer, filtermass washer, combination cock as will be directed.

EXHAUST PIPING.

Provide *one main* exhaust pipe. Connect the exhaust outlets of *engines, and collect* exhaust from all pumps into it. Place valve

at all connections. The main exhaust pipe to be connected to heater, also to the steam condenser in ice plant, and to coil in hot water tank. From heater run galvanized iron pipe to outside of building and place exhaust head on top. Make drip and blow-off connections to iron blow-off basin. Connect blow-off from boilers to this basin and run four-inch cast-iron pipe to next catch basin. Make the proper drips for engines and pumps.

WATER PIPES.

Connect the discharge from boiler feed pump to heater and reboiler complete. Form a discharge header of four-inch openings, one for each boiler, one for hot water tank, one for reboiler, each with separate valve. From these openings run pipes separately to points named. Place safety valve near heater, connect complete, put on water gauge, overflow and vapor pipe. Connect suction of boiler pump to water main, and to receiving tank. Connect the water pump and provide full-sized standpipe to top floor of brew house, also make connections to all water tanks. Leave opening at each floor, with cock for hose connections. Make connections to water tank, underlet (pfaff), rice tub and water part of Baudelot cooler. Discharge water from Baudelot cooler into hot water tank and make provision also to run it into sewer. Put standpipe in stock house connected to water tank and provide cocks for hose in each floor. Connect water pipe also to beer pumps in order to force up the last beer in pipes. Beer pipes to be put together with flanges, so that they can be taken apart and cleaned. Connect one beer pump to grant and discharge into mash tub and also into rice tub, so that the water sprinkled over grain can be used for the next brew, and make suction to Baudelot cooler pan and discharge to settling tubs. Connect suction of large beer pump to hop-jack and discharge into beer tank.

HOT WATER CONNECTIONS.

Run pipe from hot water tank to mash tub pfaff, also to rice tub and oversprinkler in mash tub and hop-jack. Make proper sized discharge from rice tank to mash tub with gate valve. Connect waste and overflow from all brewery tanks to soil pipes. Put up thermometer on hot water tank and mash tub. Provide scales with swimmers on water tanks. Furnish and erect one artesian or shallow well pump, as will be directed, and make proper connections to ammonia condensers.

Connect the suction pipe of air pump to outside of building and the discharge to chip cask cellar, and provide regulating valve. Make all necessary steam and water connections to the artificial ice plant.

PIPE COVERING.

Cover sides and bottom of the steam brewing kettle, sides of mash tub, rice tub and hot water tank, with the selected insulating material in the best approved manner.

All live steam pipes, elbows, etc., to be covered with sectional covering. Give prices for covering of tanks per square foot, and for pipe covering per lineal foot for the different sizes of pipes.

LIGHTNING RODS.

Contractor must give estimate on rods, ½ in thick, of solid twisted copper wires, and also on copper covered rods with iron or steel centers, not less than ¾ inch diameter. Sections of rods must be screwed together with good copper connections, so as to make it continuous, and wherever branches are made a copper T burr must be used. All points must be of the bayonet pattern, gold-plated and platinum tips. All fasteners to be of malleable galvanized iron. All insulators to be of glass and large enough for the rod to pass through. Where rods enter the ground they must be encased in 1½-inch gas pipes, not less than six feet long. Ground rods must be placed in trenches and extend not less than ten feet from building, and then penetrate the ground not less than ten feet perpendicularly. There must not be more than five points to one ground rod. No holes must be cut in roofs, but rods fastened to walls as much as possible. Where it becomes necessary to cross the roofs, two-inch by four-inch crosses to be used and fasteners and insulators placed on same. To tin and slate roofs fasteners must be screwed carefully, flashed around and solder run all around fasteners to make it perfectly water-tight.

APPLIANCES AND APPARATUS.

Specifications for following are obtained from their manufacturers: Elevators and conveyors, pumps for boiler feed, racking off, mash tub vorlauf, cellar pumps, wort pumps, etc., hopper scales, belts, kettle, mash tub and support, copper false bottom and grant, hop-jack, rice tub, hot and cold water tanks, beer tank or surface cooler, *Baudelot* cooler copper part, cooperage, wash *house and pitching* machines, boilers and heaters, engines, lighting.

CHEMISTRY.

Chemistry is that science which treats of such changes in bodies as permanently affect their properties; that is, produce new bodies. Chemistry is generally divided into:

"Synthetical" chemistry, which teaches how the compound bodies are built up from simple bodies, and

"Analytical" chemistry, which teaches how to decompose bodies into simpler substances.

From ancient times the question has been debated whether matter could be divided into infinitely small particles, or only to a limited degree. We have no means of deciding such a question. It is, however, assumed that matter cannot be divided beyond a certain limit.

"Atoms." To a particle of the smallest size in which matter can exist, the name of atom has been given.

"Molecules." Two or more atoms, held together by a force called "chemical affinity," constitute a molecule.

"Masses." Two or more molecules, held together by a force called "cohesion," constitute a mass. A piece of chalk is a mass made up of billions of molecules, and each molecule of chalk is made up by the union of five atoms of three different kinds. Matter, therefore, is made up of atoms, molecules and masses. Atoms do not exist alone. If an atom is separated from one molecule, it immediately joins other atoms and produces new molecules.

"Compound Bodies" and "Elements." If all the atoms in a molecule are of the same kind, the molecule is said to be a "simple" or "elementary molecule;" if the atoms are of different kinds, the molecule is said to be "compound." Substances whose molecules are compound are called "compound substances." Of this kind are most substances found in nature, as water, stones,

soil and all the different substances that go to make up plants and animals. Substances whose molecules consist of only one kind of atoms are called "elements." Most of these are in combinations; few only are found free in nature (native). Of this kind are carbon, sulphur, phosphorus and various metals, as gold, silver, copper, etc.

Of these simple substances, or elements, a little over seventy are known. Many of them are very scarce and of no practical value. The most important of the elements are enumerated in the table on the next page.

The elements, either by themselves or in a variety of combinations with each other, constitute the whole visible world. The variety of objects in nature is, therefore, more apparent than real. The air is a mixture of oxygen and nitrogen; water is a combination of oxygen and hydrogen; all plants and animals are largely made up of four elements, viz., carbon, oxygen, hydrogen and nitrogen.

CHEMICAL COMBINATION AND MECHANICAL MIXTURE.

In a mechanical mixture the several substances of which it is composed may be present in any ratio. Sand and lime may be mixed in different ratios, copper filings and iron filings added together in varying quantities, and afterward the several substances may be separated by mechanical means. The lime may be sifted from the sand, the iron filings withdrawn from the copper by means of a magnet.

A chemical combination is far more intimate and of a different nature. If two substances enter into a chemical combination, one or more atoms of one substance unite with one or more atoms of the other substance into a molecule of a new substance, which has properties entirely different from those of the two original substances.

If powdered sulphur is mixed with fine iron filings, the result is a mechanical mixture of sulphur and iron. With the help of a magnifying glass we can detect particles of iron and particles of sulphur in the mixture, and the iron can easily be separated from the sulphur by mechanical means.

If, however, this same mixture is heated, then the sulphur melts and is thereby brought into closer contact with the iron, one atom of sulphur takes hold of one atom of iron and forms a molecul

TABLE OF THE MOST IMPORTANT ELEMENTS, WITH SYMBOLS AN ATOMIC WEIGHTS.

Name of Element—	Symbol.	Atomic Weight.	
Oxygen	O	16	
Hydrogen	H	1	
Nitrogen	N	14	
Carbon	C	12	
Sulphur	S	32	
Chlorine	Cl	35.5	Non-metallic Elements.
Iodine	I	127	
Bromine	Br	80	
Fluorine	F	19	
Phosphorus	P	31	
Silicon	Si	28	
Boron	B	11	

Name of Element—	Symbol.	Atomic Weight.	
Potassium	K	39.1	
Sodium	Na	23	
Lithium	Li	7	
Calcium	Ca	40	
Barium	Ba	137.4	Light Metals.
Strontium	Sr	87.6	
Magnesium	Mg	24.4	
Aluminum	Al	27.1	
Beryllium	Be	9.4	
Thorium	Th	232.5	
Zirconium	Zr	90.6	

Name of Element—	Symbol.	Atomic Weight.	
Iron	Fe	56	
Manganese	Mn	55	
Chromium	Cr	52.2	
Uranium	U	239.4	
Cobalt	Co	59.6	
Nickel	Ni	58.8	
Zinc	Zn	65.4	
Lead	Pb	207	Heavy Metals.
Copper	Cu	63.6	
Bismuth	Bi	210	
Mercury	Hg	200	
Silver	Ag	108	
Gold	Au	197	
Platinum	Pt	194.8	
Tin	Sn	119	
Arsenic	*As*	75	
Antimony	*Sb*	120	

of a new substance, called "sulphide of iron," which resembles neither the iron nor the sulphur. In this new substance neither sulphur nor iron can be detected by any mechanical means.

A chemical combination differs from a mechanical mixture in this, that the two or more substances which constitute a chemical combination unite in certain invariable ratios. Thus we find that if sulphur and iron combine, 56 parts by weight of iron unite with 32 parts of sulphur to produce 88 parts of sulphide of iron.

If more iron is added, it is left out of the combination, and retains its original form. The fact that different elements unite in certain ratios only, has led to the acceptance of the theory of the existence of atoms.

ATOMIC WEIGHTS.

Atomic weights are the weights of the atoms of the different elements, compared to the lightest atom of them all, that of hydrogen, the weight of which is called 16 An atom of iron is 56 times as heavy as an atom of hydrogen, and an atom of sulphur 32 times the weight of the hydrogen atom, hence the atomic weight of iron is said to be 56 and of sulphur 32. If sulphur and iron unite, one atom of iron combining with one atom of sulphur, the weight of the iron is to the weight of the sulphur as 56 is to 32; that is, in a combination of this kind, between sulphur and iron, every 56 pounds of iron and 32 pounds of sulphur make up 88 pounds of the compound.

SYMBOLS.

Instead of the full names of the elements, symbols are generally used to represent them, being, in most cases, the first letters of the Latin equivalents of their names.

NON-METALLIC ELEMENTS.

OXYGEN. Atomic weight, 16, Symbol O.

Oxygen is the most important of all elements. It sustains animal life and all ordinary combustion. In a free state, that is, not combined with any other element, it is found in the air of which it constitutes one-fifth part. Pure oxygen is, like air, a colorless, odorless and tasteless gas. Bodies which burn in air, burn with much greater energy and brilliancy in pure oxygen.

Oxidation.—If a substance burns, or undergoes combustion, it unites chemically with oxygen. The burnt body is said to be "*oxidized.*" The ordinary burning of coal marks a chemical com-

bination between the coal (or carbon) and oxygen. The new body which results is called carbonic acid gas. The fact that this new body is a gas, makes it appear as if the coal had been destroyed in burning. Such is, however, not the case. Every particle of the coal is found, after the burning, in the carbonic acid gas produced by combustion. Every 12 pounds of coal give 44 pounds of carbonic acid gas.

"Slow Combustion."—Combustion is not always accompanied by great heat and light. Coal (or carbon) can burn at a low temperature as completely as at a high. Respiration in animals is combustion of this type, during which the carbon in the blood is burnt at a temperature of 98° F. It is this slow combustion that generates heat in the animal body.

Oxygen being present almost everywhere, acts upon nearly all bodies, producing modifications. The decay of plants, the corrosion of metals, are changes of a similar nature to combustion.

HYDROGEN.—Atomic weight 1, Symbol H.

Hydrogen, like oxygen, is a colorless, tasteless, and odorless gas. It is the lightest of all elements, fourteen times lighter than air, the weight of its atom is therefore taken as a unit. Hydrogen is not found in a free state; wherever it occurs in nature it is always combined with some other element.

Such a combination is water, which is composed of 1 part by weight, of hydrogen and 8 parts by weight, of oxygen. An electric current conducted through water will decompose it. At the negative pole of the battery, that is, where the wire from the zinc-plate is immersed in the water, hydrogen is generated, and at the positive pole, that is, where the wire from the copper-plate dips into the water, oxygen is disengaged. If the two gases are collected in graduated jars, it is found that the volume of hydrogen is twice as large as that of oxygen. As equal volumes of gases under equal pressure and at the same temperature contain equal numbers of molecules, it follows that water contains two atoms of hydrogen combined with every single atom of oxygen.

To express this ratio between the atoms in the different compound bodies, chemistry uses certain formulæ in which each atom is expressed by the symbol of the element. Thus the chemical *formula of water is* H_2O, signifying that two atoms of hydrogen *are combined with* one atom of oxygen. The atomic weight of *hydrogen being* 1, and of oxygen 16, the formula also indicates

that in a certain quantity of water, the weight of the hydrogen is to the weight of the oxygen as 2 is to 16, or as 1 is to 8. Nine pounds of water, therefore, contain 8 pounds of oxygen and 1 pound of hydrogen.

Hydrogen gas burns in air with a pale, blue flame, that is, it unites with the oxygen of the air, and the product of the combustion is water. It can thus be said that water is burnt hydrogen in the same sense as carbonic acid can be said to be burnt coal. The two gases, hydrogen and oxygen can be mixed at ordinary temperature and kept in a vessel for any length of time without combining. That means that at ordinary temperature the molecules of oxygen and the molecules of hydrogen move around each other without any change taking place in either. But if the mixture of the two gases comes in contact with a flame, f. i., a burning match or an electric spark, the molecules in the immediate neighborhood of the hot body open up, the atoms of the oxygen and hydrogen molecules are set free, and two hydrogen atoms immediately join one oxygen atom, forming a new molecule, which consists of the two elements of hydrogen and oxygen.

In this process a great deal of energy or heat is generated, which causes the next molecule to undergo a similar change, and so the movement is transmitted through the whole mass of gas. This movement is instantaneous. If a mixture of hydrogen and oxygen is ignited, an explosion takes place. If there is twice the volume of hydrogen as of oxygen, there will be produced a weight of steam exactly equal to that of the two masses of gas together. Two cubic feet of hydrogen gas weigh—at ordinary air pressure and temperature—about 0.173 ounces; one cubic foot of oxygen, under like circumstances, weighs 1.38 ounces. If these two volumes of the gases are mixed and ignited, and the resulting steam condensed, it will be found that the water weighs 1.38 oz. + 0.173 oz., or 1.553 oz.

A high temperature facilitates chemical combustion in many cases. Coal may, at ordinary temperature, lie exposed to the air for a long period, without undergoing any perceptible change. But if heated to red heat it combines rapidly with oxygen, giving off carbonic acid gas.

The solid carbon, by combining with oxygen gas, itself becomes *a gas, whereas the* gaseous hydrogen, by combining with oxygen *gas, turns into a fluid.*

NITROGEN.—Atomic weight 14, Symbol N.

Nitrogen is also a colorless and odorless gas. Mixed with oxygen it makes up the atmosphere, which consists of about $\frac{4}{5}$ nitrogen and $\frac{1}{5}$ oxygen, together with a small quantity of carbonic acid gas. Unlike oxygen, nitrogen does not readily enter into combinations with many other elements. In an atmosphere of nitrogen alone, there could be no combustion, as neither coal nor hydrogen, nor any of the metals, even if heated to a high temperature (as by a powerful electric current) will unite with nitrogen.

For the same reason nitrogen cannot support animal life. In the process of respiration the nitrogen of the air taken into the lungs is exhaled unchanged, only the oxygen being absorbed by the body. If a large number of people are crowded in a room which is without ventilation, a feeling of suffocation is soon experienced, which is caused by the decrease of oxygen. If the amount of oxygen in air is reduced to a certain limit, a candle will not burn in such an atmosphere, as the nitrogen cannot sustain combustion.

AMMONIA.

Nevertheless, nitrogen enters largely into the composition of vegetable and, still more, of animal substances. Plants and animals are mainly composed of oxygen, hydrogen, nitrogen and carbon. Plants receive their oxygen and hydrogen from water, the carbon from the carbonic acid of the air, and the nitrogen from a substance called "ammonia," which is a combination of hydrogen and nitrogen, and is always present in the soil.

When plants die and decay, these same substances, water, ammonia and carbonic acid, are all released from the more complicated combinations in the plants, and resume their elementary forms. The ammonia of the dying plant is to some extent absorbed by the soil and gives nourishment to a new crop. After successive crops have deprived the soil of a large share of the ammonia it contained, the deficiency must be made up by introducing some substance that is rich in ammonia, such as stable manure. Ammonia is also produced when coal is distilled for making illuminating gas. Coal contains small quantities of hydrogen and nitrogen, and in the heat of distillation they unite and produce ammonia, which collects in the water through which the gas is led to be purified. From this source comes the largest part of commercial ammonia.

Under ordinary air pressure and temperature, ammonia is a gas possessing a strong, pungent odor. Water absorbs large quantities of ammonia and acquires the odor of the gas. This solution of ammonia gas is called "ammonia water," or "aqua ammonia."

LIQUID AMMONIA.

Ammonia gas can be condensed to a fluid by cooling it below —40° F., or by subjecting it to a pressure of 60 pounds per square inch at a temperature of 32° F. If this liquid ammonia is exposed to any temperature above —40° F. or the pressure on it removed, it comes to a boil. If a thermometer is held in the boiling liquid it sinks to nearly —29° F. The heat consumed in keeping up the boiling is taken from the adjoining objects, which are thereby cooled to a low temperature. On this observation is based the use of liquid ammonia for producing artificial ice and for cooling purposes.

When nitrogen and hydrogen combine to form ammonia one volume of nitrogen unites with three volumes of hydrogen, hence the chemical formula of ammonia is NH_3. As the atomic weight of nitrogen is 14 and of hydrogen 1, the formula also indicates that 14 parts, by weight, of nitrogen, combine with 3 parts of hydrogen, to create 17 parts of ammonia.

NITRIC ACID.

Nitrogen can also be made to combine with oxygen, although with difficulty. If electric sparks are passed through a moist mixture of nitrogen and oxygen, these two gases combine with each other and the water into a substance called "nitric acid," a colorless corrosive fluid, which dissolves nearly all metals.

If a piece of copper is dropped into nitric acid, red fumes are generated, the fluid assumes a blue color and after awhile the copper has disappeared. If the resulting blue solution is evaporated slowly, blue crystals begin to form. These crystals are a combination of copper and nitric acid.

SALTS.

Such a substance as is formed by the action of an acid on a metal is called a salt. A salt is named from the metal and the acid that enter into its make-up. Thus the above described salt is called "nitrate of copper."

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In Northern Peru are found beds of great extent, consisting of a salt called Chili saltpetre. This salt is a combination of the metal sodium and nitric acid, and its chemical name is "nitrate of sodium." This salt is used for the manufacture of nitric acid.

CARBON.—Atomic weight 12, Symbol C.

The element of carbon is found in a pure state in two distinct forms, as diamond and as graphite or plumbago. Ordinary coal and charcoal is carbon, a small part of which is combined with hydrogen and nitrogen, and mixed with mineral substances which remain behind as ashes, when the coal is burnt. Carbon also constitutes a large share of all animal and vegetable matter. If such substances, f. i., meat and wood, are heated in closed vessels, the volatile parts, such as water, ammonia, etc., are expelled and the charcoal remains behind.

CARBONIC ACID.

If carbon is heated in oxygen or air, it burns, that is, it unites with oxygen. The new substance which is formed by the chemical combination of the two elements, carbon and oxygen, is, under ordinary circumstances, a gas called carbonic acid. It consists of 12 parts, by weight, of carbon and 32 parts of oxygen. Its chemical formula is CO_2, expressing that one atom of carbon has taken up two atoms of oxygen. The coal that apparently disappeared during combustion, has in reality formed a new body, which weighs more than three and one-half times as much as the coal.

Carbonic acid, also called carbon dioxide, is a colorless gas, of an agreeable, pungent taste and smell. It is 1½ times as heavy as air. The gas is very injurious to animal life, when taken through the respiratory organs, even if diluted with air. A lighted candle is instantly extinguished in carbonic acid gas, for, although it contains much oxygen, this oxygen is already united with all the carbon it can consume.

Water of 63.5° F. absorbs a volume of carbonic acid equal to its own, whatever be the density of the gas. Under heavy pressure water can, therefore, be charged with large quantities of the gas (sodawater).

Carbonic acid is found in the air in small quantities (4 volumes of carbonic acid gas in 10,000 volumes of air). Plants have the power of absorbing this carbonic acid of the air, and, in the sun-

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light, dissociating it, retaining the carbon and exhaling the oxygen. As the animals inhale oxygen and exhale carbonic acid, the respiration of plants and animals is interdependent and reciprocally corrects itself.

Carbonic acid is also generated in large quantities in the process of fermentation. The sugar in the wort is composed of three elements: carbon, oxygen and hydrogen. By the action of yeast the sugar is broken down, and part of its carbon and oxygen unite to produce carbonic acid. Thus fermentation affords an example of a slow combustion of carbon, a combustion without light, but not without heat, as the temperature of the wort rises considerably during fermentation. A small portion of the carbonic acid formed during fermentation remains in the beer, imparting to it the prickling taste and causing it to foam by escaping under reduced pressure.

By great pressure and cooling, carbonic acid gas can be compressed into a liquid, colorless and lighter than water. If the pressure is released and the liquid allowed to be volatilized, intense cold is produced.

SULPHUR—Atomic weight 32, Symbol S.

The element of sulphur is often found in nature in a free state, that is, not combined with any other element.

If sulphur is heated without contact with air it melts at 232° F., and boils at 800° F. If the vapors are conducted into a cold place, it condenses to a fine flour called flower of sulphur. On the other hand, if sulphur is heated in air, it ignites and burns with a pale, blue flame. The sulphur disappears in a similar way as burning coal, and the reason is that here, also, the product of combustion is a gas. This gas has a strongly suffocating odor, and extinguishes a flame. The gas is called sulphurous acid.

SULPHUROUS ACID OR SULPHUR DIOXIDE.

The disinfecting property of this gas has been known from time immemorial. Being an acid, the gas can combine with several metals forming salts, and it is in this form that it is mostly used nowadays. These salts are called "sulphites," and the ones most commonly used are "bisulphite of sodium," "bisulphite of lime" and "meta-bisulphite of potassium" (K. M. S., or "Kalium Meta-Sulphite"). *Sulphurous* acid gas also has bleaching properties, *used for improving* the color and keeping quality of hops and

sometimes to fraudulently "improve" the color of damaged barley. A red colored flower, if exposed to the gas, is quickly bleached white.

SULPHURIC ACID.

With the aid of nitric acid fumes and steam, sulphurous acid can be made to take up more oxygen and changed to a new acid, called sulphuric acid, or oil of vitriol. Like nitric acid, sulphuric acid is a very corrosive fluid, colorless, when pure, and nearly twice as heavy as water. It also dissolves most metals, forming salts that are called "sulphates." Iron, dissolved in sulphuric acid, thus gives sulphate of iron (green vitriol); copper and sulphuric acid give sulphate of copper (blue vitriol); lime and the acid form sulphate of lime (plaster of Paris, gypsum).

Sulphur also combines with hydrogen, producing a gas called sulphuretted hydrogen, which has the odor of rotten eggs, and is generally contained in sewer gas.

CHLORINE—Atomic weight 35.5, Symbol Cl.

Chlorine is a heavy, greenish-yellow gas, strongly suffocating and poisonous. It combines with hydrogen into a colorless, corrosive gas, called "hydrochloric acid." Like sulphuric and nitric acid, it dissolves most metals and forms salts which are called "chlorides." Common table salt is a combination of this acid and the metal sodium, and the chemical name of table salt is chloride of sodium. The three acids, sulphuric, nitric and hydrochloric (or, as it is called, muriatic) are manufactured in enormous quantities and used for various industrial purposes.

BROMINE—Atomic weight 79.96, Symbol Br.

Bromine is a heavy brownish-red liquid, which at ordinary temperature gives off red vapors of a strongly suffocating odor. Combined with metals, this element forms salts which are called "bromides." Bromide of potassium is largely used as a nerve tonic.

IODINE—Atomic weight 127, Symbol I.

Iodine is a solid body of a bluish-black color. When heated it boils at 347° F. The vapor has a beautiful violet color. It is in many respects like chlorine and by uniting with metals produces salts that are called "iodides." With the potassium metal it forms iodide of potassium, a salt that in appearance is very much like common table salt.

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A solution of this salt in water has the power of dissolving iodine to a dark red solution, which is called "iodine solution," and is used to detect starch. If a drop of iodine solution is introduced into a cold solution of starch, a deep blue color is produced by a combination of iodine with starch. Very small amounts of starch in wort or beer can be detected by means of this solution.

FLUORINE—Atomic weight 19, Symbol Fl.

Fluorine can hardly be isolated at all, as it attacks, and combines with, nearly all other bodies. It is very similar to chlorine, very poisonous and corrosive. With ammonia it forms a salt called "acid fluoride of ammonium," which is used as an antiseptic. The magnesia and lime salts being insoluble, the soluble fluorides may be used as boiler compounds.

PHOSPHORUS—Atomic weight 31, Symbol P.

Phosphorus is a yellowish-white substance, very much like wax. It is very inflammable and poisonous. When heated it burns with a bright flame and unites with oxygen to a substance called "phosphoric acid." Phosphoric acid enters into combination with many of the metals and the resulting salts are called "phosphates." Most of them are insoluble, like the phosphates of lime and magnesia; hence, the soluble phosphates, like that of soda, can be employed as boiler compounds. The phosphates are taken up from the soil by the plants, and from the plants they pass into the bodies of animals. Phosphates are a necessary nutriment for both animals and plants. They can be used to strengthen yeast.

SILICON—Atomic weight 28, Symbol Si.

The element of silicon is never found as such in nature. United with oxygen, however, it is a very abundant substance, and of great importance. All rocks and mineral masses of which the surface of the earth is made up, are largely composed of silica, which is the element silicon combined with oxygen according to the chemical formula SiO_2, that is, containing 28 parts of silicon and 32 parts of oxygen.

Silica is taken up by plants and is found in the straw and hull of grain.

BORON—Atomic weight 11, Symbol B.

Boron is contained in borax, a salt found in Asia, South America, California and Italy. Ordinary borax is a combinatio

of sodium and boracic acid. It is largely employed as a preservative for meats, fruits, etc., for soldering, for softening hard waters, and in place of soap.

THE METALS.

The second and larger group of elements, which are embraced under the name of metals, is generally divided into two classes, viz.: "The light metals," of which the most important are potassium, sodium, calcium, magnesium and aluminum, and "the heavy metals," the best known of which are iron, manganese, nickel, zinc, lead, copper, mercury, silver, gold and platinum.

Of the light metals only magnesium and aluminum are of considerable importance, in a metallic state. Potassium, sodium and calcium are mostly used in the form of oxides or as salts.

The heavy metals, on the contrary, are of the greatest importance in the metallic state.

LIGHT METALS.

POTASSIUM—Atomic weight 39.1, Symbol K.

The metal of potassium is white and soft; it is lighter than water, its specific gravity being only 0.86. Upon exposure to the air it combines directly with oxygen and forms oxide of potassium. The chemical formula of this substance is K_2O, indicating that two atoms of the metal unite with one atom of oxygen, or, by weight, 2×39.1 or 78.2 parts of potassium with 16 parts of oxygen.

If potassium metal is thrown upon water it takes fire and burns with a purple flame. It is the oxygen of the water that unites with the metal; the hydrogen of the water is thus set free and ignited by the heat developed by the combination of the metal and the oxygen. The resulting oxide of potassium is dissolved in the water and when the water is evaporated there remains a white substance called potassium hydrate or, generally, caustic potash. As the potassium metal is oxidized both in the air and in water, it is kept in naphtha, a substance that does not contain any oxygen.

Potassium forms salts with the different acids. The most *important of these* are:

"Carbonate of potassium," extracted from the ashes of plants. *The crude product is* the pearlash, or crude potash of commerce.

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"Nitrate of potassium," or saltpetre, used in the manufacture of gunpowder.

"Meta-Sulphite of Potassium" used as an antiseptic.

SODIUM—Atomic weight 23, Symbol Na.

The metal of sodium is in nearly all respects like potassium. It is a very abundant element. Like potassium it oxidizes very rapidly in the air, takes fire when thrown upon water, and then forms "caustic soda." The most important sodium salts are:

"Carbonate of Soda," manufactured in great quantities from common salt. It is sometimes found in natural waters, which are then said to be alkaline. Such waters are unfit for brewing.

"Soda Ash" is a crude product obtained from the sulphate of soda used in the production of carbonate of soda, containing. besides carbonate of soda, also caustic soda, sulphate of soda, and common salt.

"Bicarbonate of Soda," produced by charging carbonate of soda with more carbonic acid.

"Chloride of Sodium," or Common Salt, which is found in nature dissolved in the water of the ocean and also occurs in solid beds in many parts of the world.

"Sulphate of Soda," often contained in water, acts as an aperient (Glauber salts).

"Sulphite of Sodium," a combination of sulphurous acid (50 per cent) with sodium, and

"Bisulphite of Sodium," containing still more sulphurous acid (over 60 per cent) are both used as antiseptics.

"Phosphate of Sodium" is a combination of phosphoric acid and sodium. By adding caustic soda to a solution of this salt, another phosphate is obtained which is called "trisodium phosphate," and is used as a boiler compound, or for softening hard water. Fluoride of sodium, carbonate of sodium (soda ash) and caustic soda may also be used for this purpose.

AMMONIUM—Atomic weight 18, Symbol NH_4.

Ammonium is not an element, but a compound body called a radical, which acts like an element. It cannot exist alone, as it would immediately fall apart into hydrogen gas (H), and so-called ammonia-gas (NH_3).

This radical (ammonium) combines with acids producing *salts which, in many* respects, are similar to the correspond-

ing salts of potassium and sodium. The most common ammonium salts are the following:

"Chloride of Ammonium," or "Sal-Ammoniac," obtained from the gas water of gas works.

"Carbonate of Ammonium," or salt of hartshorn, obtained by the dry distillation of bone and other animal matter. Can be used to strengthen yeast.

CALCIUM—Atomic weight 40, Symbol Ca.

Calcium is one of the most abundant of the metals, but never occurs in a free state. The metal is yellow, its specific gravity 1.58. When heated it burns with a bright light to a white powder, which is "oxide of calcium," or "burnt lime" (CaO). When this is moistened with water, it slacks with great violence, giving off a large amount of heat and crumbling to a soft, white powder. This "slack lime" is a chemical combination of the oxide of calcium, CaO, and water, H_2O, and its formula is $Ca(OH)_2$. It is soluble in water to a certain extent, the solution being called "limewater."

Burnt lime unites with carbonic acid and produces "carbonate of lime," which, as limestone or marble, makes up whole mountain ranges. It is slightly soluble in water. When heated to red heat the carbonic acid is expelled, and burnt lime is left behind. Although nearly insoluble in water, carbonate of lime is taken up by water containing carbonic acid. Since rainwater, falling through the air or passing through the soil, is charged with carbonic acid, most natural waters, like those of springs, rivers and lakes, contain lime.

Such waters, containing large amounts of carbonate of lime in solution, are called hard waters. The lime in the water is in the form of the bicarbonate, which differs from the carbonate by containing more carbonic acid.

The property of water caused by carbonate of lime is called "temporary hardness," since it can be diminished by boiling the water. If hard water is boiled one part of carbonic acid escapes from every molecule, changing the soluble bicarbonate of lime to the insoluble carbonate, which is precipitated as a white powder. Boilers in which such water is heated soon become lined with a stony crust, generally called "boiler scale."

"Sulphate of lime" is a combination of lime and sulphuric acid, and is found in some localities in large quantities, combined with

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water as gypsum. Plaster of Paris is burnt gypsum, or gypsum freed from water. When plaster of Paris is moistened it takes up water again and forms gypsum. Being slightly soluble in water, gypsum is also found in many natural waters.

"Bisulphite of Lime. When sulphurous acid gas is led into limewater, or milk of lime, it is speedily absorbed, thereby forming bisulphite of lime, which is a strong disinfectant.

MAGNESIUM—Atomic weight 24, Symbol Mg.

The metal of magnesium is white and light of weight. When ignited it burns with a dazzling, bluish-white light to a white powder, which is oxide of magnesium. In a natural state magnesium often accompanies lime. Thus, it is found together with limestone as carbonate of magnesium, and in many natural waters as bicarbonate of magnesium, producing hardness like the lime salt. When such water is boiled, the bicarbonate of magnesium is precipitated and becomes carbonate of magnesium.

ALUMINUM—Atomic weight 27.1, Symbol Al.

Aluminum is very abundant in nature. Combined with silica it forms many minerals, and it is a constituent of the various modifications of clay. The metal of aluminum is nearly as white as silver and very light, its specific gravity being 2.6, whereas that of silver is 10.5. It is not poisonous. Weak acids do not affect it, which makes it suitable for cooking utensils or receptacles for food and beverages.

"Oxide of Aluminum," or the burnt metal, also called alumina constitutes the greater part of clay.

"Alum" is a combination of sulphate of potassium and sulphate of aluminum.

MISCELLANEOUS METALS.

The elements of barium, strontium, beryllium, thorium and zirconium occur less frequently.

"Barium" is found in nature as "heavy-spar," a combination of barium and sulphuric acid. Barium chloride is used by chemists as a means of detecting and determining sulphuric acid.

"Strontium." The nitrate of strontium is used in the manufacture of fireworks. It imparts a red color to fire.

"Thorium" is found as a rare mineral, combined with silica. *It has lately been used* for producing glow lights (Welsbach *light), the mantles* of which are composed largely of oxide of *thorium.*

HEAVY METALS.

Iron—Atomic weight 56, Symbol Fe.

Iron, the most important of all the metals, is very seldom found in nature in the metallic state. Combined with oxygen, it is found everywhere. The reddish tints in rocks and soil are almost entirely due to iron oxides, nearly all natural waters contain more or less carbonate of iron; it is contained in plants and in the blood of the animal body. Pure metallic iron has a white color, is quite soft and tough; its specific gravity is 7.8.

Iron combines with oxygen in varying ratios, and thus forms oxides of iron of different compositions. The most common is the "ferric oxide," which, when combined with water, is called rust.

"Iron Ores." The oxides and the carbonates of iron are the natural products from which metallic iron is obtained. They are called iron ores. These ores are mixed with coal in large furnaces and heated to a high temperature. The coal, under such circumstances, has the power of withdrawing the oxygen from the oxides of iron and uniting with it to carbonic acid. The metallic iron, being thus liberated, melts and sinks to the bottom of the furnace, whence it is drained off. This crude iron, which contains a good deal of carbon (from 2.5 per cent to 6 per cent), melts at a lower temperature than pure iron, and is called pig-iron, or, after remelting, cast-iron.

Bar Iron. If the cast-iron is remelted and the largest part of the carbon and other impurities are removed by oxidation the resulting iron is called bar iron or malleable iron. Bar iron is almost pure iron, containing only 0.2 to 0.6 per cent carbon, and two pieces of it, when heated to white heat, can be hammered together, which operation is called "welding."

Steel. When bar iron is heated to full red heat, while in contact with carbon, it takes up 0.8 to 1.8 per cent of carbon, and thereby becomes harder. It is changed into steel. Bessemer steel is produced by forcing air into molten cast-iron. When enough of the carbon of the cast-iron has been oxidized, the current of air is stopped, and the molten metal run into ingot-molds. *When steel is heated* to redness and then submerged in cold water, *it becomes so* hard that it scratches glass. If reheated to *redness, and allowed* to cool slowly, it again becomes almost as

soft as iron, and any degree of hardness, between these two conditions may be attained (tempering).

Iron combines with the acids and forms salts. The most important of these is "sulphate of iron," commonly called green vitriol. or copperas, which forms large, green crystals.

"Bicarbonate of Iron" is found in a state of solution in many spring waters. When such water is heated or exposed to the air, the iron is precipitated as a reddish deposit of oxide of iron, commonly called rust.

NICKEL—Atomic weight 58.8, Symbol Ni.

Nickel is a white, malleable metal of a high melting point, and a specific gravity of 8.6. It does not oxidize so easily as iron, and dilute acids affect it but little. Consequently it does not tarnish in the air, and sulphur fumes do not blacken it. Nickel can be welded with wrought iron, and such combination rolled out into very thin sheets. Iron can also be coated with nickel by the ordinary processes of electroplating. Nickel electroplating was invented by Böttger in 1848, and has developed into an important industry.

ZINC—Atomic weight 65.4, Symbol Zn.

Zinc has a bluish-white color and tarnishes slowly in the air. The specific gravity of zinc varies from 6.8 to 7.2. At ordinary temperature the metal is brittle, but becomes malleable at 250° to 300° F. At this temperature it is rolled into sheets, after which treatment it remains malleable when cold. At 410° F.. it becomes so brittle that it may be powdered. It melts at 773° F., and at a bright red heat it boils, and, in the presence of air burns with a greenish flame to "zinc oxide," also called "zinc white," the "philosophical wool" or "flowers of zinc" of the alchemists, which is used as a pigment (enamel paint). Dilute acids dissolve zinc readily, and form salts, the most important of which is "sulphate of zinc," or "white vitriol"; "zinc chloride" used in tinning and soft-soldering copper and iron. "Galvanized iron" is iron coated with zinc.

COPPER—Atomic weight 63.4, Symbol Cu.

Copper is sometimes found in a natural state as metallic copper. It is of a yellowish-red color, has a specific gravity of 8.9, and is very malleable. It is a very good conductor of heat and electricity. *Copper undergoes* no change in dry air, but in a moist at*mosphere it is covered* with a green coat, which consists for the

most part of "carbonate of copper." Dilute sulphuric and hydrochloric acids act but slightly upon copper, whereas nitric acid dissolves it readily. The most common salt of copper is the "sulphate of copper," commonly called "blue vitriol." "Verdigris" is acetate of copper. "Paris green" consists of copper, acetic acid and arsenious acid.

LEAD—Atomic weight 207, Symbol Pb.

Lead is found in nature combined with sulphur in the so-called galena, which is the principal lead ore. Lead is a bluish-white metal, very soft and plastic. The specific gravity of lead is 11.35. It melts at 633° F. In ordinary air it tarnishes rapidly, but the thin coat of oxide increases very slowly. When heated to melting in the presence of air, lead rapidly absorbs oxygen and forms oxides of different composition. "Litharge" is an oxide of lead which forms dark, yellow scales, and is used for making lead salts, oil varnishes and for many other purposes. "Minium" or "red lead" is another oxide of lead, which is used as a pigment and for making certain cements. Of the lead salts the most important are carbonate of lead or "white lead," which is used in paints, and acetate of lead which, on account of its sweetish taste is also called "sugar of lead."

MERCURY—Atomic weight 200, Symbol Hg.

Mercury, also called quicksilver, is liquid at all ordinary temperatures, and congeals at —40° F. At 662° F. it boils. The specific gravity is 13.59. It is used extensively in thermometers and barometers.

SILVER—Atomic weight 108, Symbol Ag.

Silver is found in nature in the metallic state, and also combined with sulphur, chlorine and other elements. The greater part of the silver is extracted from its ores by smelting, or by extracting it with mercury, which dissolves the silver to a mixture called amalgam. Pure silver is of a nearly white color, very malleable, and is the best conductor of heat and electricity. Its specific gravity is 10.5. Silver does not change in air or moisture, but blackens if the air contains sulphuretted hydrogen. The most important salts of silver are: "Chloride of silver," in the *native state* called "horn silver"; "nitrate of silver" also called *"lunar caustic."*

GOLD—Atomic weight 196.7, Symbol Au.

Gold is also found in nature in a metallic state, often combined with silver, both in regular mineral veins in quartz and in the sands of many rivers. Pure gold is soft and can be hammered out into exceedingly thin leaves. The specific gravity is 19.5. It is perfectly unchangeable in air and moisture, no single acid attacks it, but a mixture of nitric and hydrochloric acids, called "Aqua regia," dissolves it to chloride of gold.

PLATINUM—Atomic weight 197.4, Symbol Pt.

Platinum is always found in the metallic state. Although one of the so-called precious metals, it lacks the fine color and luster of gold and silver, and is, therefore, not much used for articles of ornament. Nearly all platinum is made into chemical utensils, for which it is eminently adapted, being infusible and not attacked by acids except by aqua regia. Platinum is used extensively for scientific purposes. The specific gravity is 21.5.

TIN—Atomic weight 119, Symbol Sn.

Tin is mostly found as oxide of tin. Pure tin is white, soft and malleable. Air and water affect it but little. The specific gravity of tin is 7.3 and it melts at 457° F. The metal rolled into thin sheets and further beaten out with wooden mallets is called "tin-foil." The ordinary "sheet-tin" is tinned iron. Tin is also used as a protecting coating for iron and copper (tinning).

ANTIMONY—Atomic weight 120, Symbol Sb.

Antimony occurs mostly in the state of sulphide. The metal is bluish-white, and very brittle, and is an important constitutent of several alloys. Antimonial preparations are used medicinally, the best known being "tartar emetic," a tartrate of potash and antimony.

ALLOYS.

When two or more metals are melted together the combination is called an alloy. Few metals are used in a pure state for industrial purposes as the pure metals seldom have the qualities necessary for special applications. Gold and silver in a pure state are too soft, and are, therefore, hardened by an addition of about a tenth part of copper. The most common and important alloys are:

Name—	Composition—
Aluminum-bronze	Aluminum and copper.
Brass	Copper with 28 to 34 per cent of zinc.
Gun metal	Ninety parts of copper and 10 parts of tin.
Bronze	Copper and tin in varying proportions.
Pewter	Tin hardened with a little antimony.
Plumbers' solder	Two parts of lead and one of tin.
German silver	One hundred parts of copper, 60 parts of zinc and 40 parts of nickel.
Britannia metal	Nine parts of tin and one part of antimony.
Type metal	Three to four parts of lead and one part of antimony.
Babbitt metal	Eighty-three to 89 parts of tin, 8 to 4 parts of copper and 8 to 7 parts of antimony.

THE CHEMISTRY OF CARBON COMPOUNDS (ORGANIC CHEMISTRY).

Originally the term "organic chemistry" denoted the chemistry of substances generated in plants and animals. When it was shown that many of these substances could be produced directly from the elements, the name of organic chemistry was replaced by the name of the "chemistry of carbon compounds." These compounds should naturally be described in connection with the element of carbon. But as they are very numerous and possess peculiar interest to the brewer, it was considered best to discuss them separately.

An organic substance, then, is a carbon compound. Organic substances contain, for the most part, only a small number of elements. Some consist only of hydrogen and carbon, as coal-oil or American petroleum. Others, such as alcohol, starch, sugar, consist of carbon, hydrogen and oxygen. Others, again, especially animal substances, contain four elements, carbon, hydrogen, oxygen, and nitrogen, for instance, the albuminoids.

But, while the number of elements in organic substances is small, the structure of the molecules is often very complex, that is, the number of atoms in each molecule is large. For that reason, they easily change to less complex substances. Thus, the molecule of grape sugar is composed of six atoms of carbon, twelve of hydrogen and six of oxygen, but if a solution of this sugar in water is mixed with yeast, the sugar molecule breaks down, forming two molecules of carbonic acid and

[redacted]

two of alcohol, both the carbonic acid and the alcohol having less complex molecules than the sugar.

ALCOHOLS.

Originally the name "alcohol" was limited to one substance obtained by the distillation of fermented liquor, and termed also spirits of wine. At present several substances are known, whose molecules are constituted in a similar way and which are also called alcohols. They are all composed of carbon, oxygen and hydrogen, but differ from each other in the number of carbon and hydrogen atoms that form their molecules.

The simplest in composition contains but one atom of carbon in each molecule; the next in order contains two, three, four, etc., atoms of carbon in each molecule.

Methylic alcohol, or "wood-spirit," is the simplest member of the series. Its chemical formula is CH_4O. The molecule is composed of one atom of carbon, four of hydrogen and one of oxygen, or, by weight, 12 parts of carbon, $4 \times 1 = 4$ parts of hydrogen, and 16 parts of oxygen for every 32 parts of the alcohol. This alcohol is obtained if wood is charred to make charcoal. The tarry liquid flowing from the retort contains small quantities of wood-vinegar and wood-spirit. The alcohol is separated from the fluid by distilling at low heat.

Methylic alcohol is a colorless, thin fluid; in a pure state it is similar in odor and taste to common alcohol, but commercial methylic alcohol has a strong, disagreeable, characteristic odor. It boils at a low temperature, namely, 152° F. It dissolves pitch, shellac and volatile oils, like common alcohol, and, being cheaper, is often substituted for the other in the manufacture of various articles.

Ethylic Alcohol, or *"Grain" Alcohol.* This alcohol which was the first known and is the most important of the whole group, is most commonly designated by the simple name of "alcohol." Its chemical formula is C_2H_6O, or, by weight $2 \times 12 = 24$ parts of carbon, $6 \times 1 = 6$ parts of hydrogen, and 16 parts of oxygen for every 46 parts of alcohol. This alcohol is produced by the fermentation of sugar by yeast. The fermented liquid is distilled and a dilute alcohol obtained, the strength of which is increased by repeated distillations.

Pure ethylic alcohol is a colorless liquid of pungent taste and odor. It has a specific gravity of 0.79. It is easily ignited,

and burns with a pale-bluish flame without smoke. It boils at $173°$ F. when free from water; in a diluted state the boiling point is the higher, the greater the degree of dilution. It can be exposed to very low temperatures without congealing. It absorbs water from the air, and can be mixed with water in any ratio. When so mixed a contraction of volume takes place, and, at the same time, the mixture becomes much warmer. Alcohol dissolves many substances that are not soluble in water, such as shellac, pitch, oils, etc.

Amylic Alcohol. In the manufacture of spirits from grain or potatoes, the ethylic alcohol is found to be accompanied by an oily fluid called *fusel oil,* or amylic alcohol. As the latter boils at a higher temperature than common alcohol, it can be separated by distillation. Thus, separated and purified, amylic alcohol is an oily, colorless liquid of a peculiar odor and burning taste. The vapor, when inhaled, produces coughing. It is not readily soluble in water, but floats on the surface like an oil.

Glycerin or glycerol is an alcohol formed in small quantities during fermentation. It is a constituent of all fats and fixed oils, from which it is obtained when the fats are decomposed by an alkali, as is done on a large scale when fats are saponified for making soap. Glycerin is a colorless syrupy liquid, of a pure, sweet taste, soluble in water and alcohol. Its specific gravity is 1.26, and it boils at $554°$ F.

ORGANIC ACIDS.

If two hydrogen atoms of an alcohol are replaced by one atom of oxygen, the alcohol is changed into an acid. Thus, if common alcohol is diluted with water and exposed to the air, oxygen is taken up by the alcohol, which is thereby changed to acetic acid, or vinegar. A corresponding acid can be produced from every alcohol. Thus, methylic alcohol being oxidized produces formic acid; ethylic alcohol yields acetic acid; butylic alcohol butyric acid; amylic alcohol, valeric acid, etc.

In wort and beer several of these acids are found, and some of them are produced by the action of bacteria on the sugar of the wort. The most important of these acids are:

Acetic Acid. This acid, when diluted with water, makes *common vinegar.* It is obtained by the destructive distillation *of wood. In this* process a sour, watery liquid, some tar, and *much gas,* pass over, while the charcoal remains in the retort.

From this fluid the concentrated acid, often called "glacial acetic acid," is prepared. It congeals below 60° F. It mixes with water in any ratio, and when diluted has a pleasant acid taste. Acetic acid is also produced by the action of certain bacteria on a dilute alcohol, and is generally found in beer, where it causes the sour taste.

Acetic acid is expelled from a solution like beer by boiling, and is called the *volatile acid* in beer. It combines with metals and forms salts, which are called "acetates." The most important are:

"Acetate of Soda," which forms large colorless crystals, readily soluble in water.

"Acetate of Lead," which is formed by dissolving oxide of lead in acetic acid. This salt generally occurs in commerce as a crystalline mass, like loaf-sugar, and from this circumstance and its sweet taste, is called "sugar of lead."

Butyric Acid is formed by the action of the butyric ferment. It is a colorless liquid, having an odor of acetic acid and rancid butter. It is sometimes found in beer and old hops.

Lactic Acid. This is the characteristic acid of beer, and, not being volatile, is also called the *"fixed acid"* of beer. It is produced by the action of certain ferments on sugar. It is found in malt and in larger quantities in beer wort. The concentrated acid is a colorless, syrupy fluid, with an intensely sour taste.

Tannic Acid is a solid body, readily soluble in water. It is found in many plants, such as hops and trees (oaks and hemlocks). It precipitates the soluble albuminoids when added to such a solution ("breaking" of the wort). *Succinic acid* produced in small quantities during the fermentation of sugar by yeast forms small white crystals.

FATS AND OILS.

Under the name of oil is included a large number of bodies, differing in chemical composition and physical properties, such as tallow, fats, fluid fixed oils, essential oils, and the so-called hydrocarbons, that is, the solid, fluid or volatile substances found in petroleum or obtained by destructive distillation. The oils may, therefore, be classified as:

1. *Fixed Oils.*
2. *Essential* or Volatile Oils.
3. *Hydrocarbons.*

I. FIXED OILS.

Fixed oils, also called fatty oils, are either of animal or vegetable origin. Those of animal origin are generally solid, and called fats, such as tallow and lard; the vegetable oils are mostly fluid at ordinary temperature, such as cottonseed oil and linseed oil.

They are all compounds of carbon, oxygen and hydrogen, and may be compared to the salts of inorganic nature, in which the place of the metal is occupied by a substance called glycerin (see under "Alcohol") and the mineral acids are represented by organic acids, called fatty acids. The fatty acids of the oils and fats are mainly oleic, palmitic and stearic acid, and the combination between these acids and glycerin, generally called olein, palmitin and stearin, form, in varying proportions, the natural oils and fats. The oleic acid is fluid at ordinary temperature, the palmitic and stearic acids are solid bodies, and such fats as chiefly consist of stearin and palmitin, as, for instance, beef and mutton-suet, are, therefore, solid bodies, whereas oils containing larger amounts of oleic acid are fluid.

If the oils are treated with an alkali (saponification) as, for instance, with caustic soda, in the presence of water, the oils are decomposed in such a way, that the fatty acids are separated from the glycerin and combine with the soda. This combination of soda and fatty acids forms the ordinary soda soap, or "hard soap;" the corresponding soap of potash, being smeary, is called "soft soap." The manufacturing of soap consists of the saponifying of fats or oils with a solution of caustic alkali.

The oils can also be decomposed by steam under a pressure of 10 to 12 atmospheres, the products of decomposition in this case being free fatty acids and glycerin.

The oils are almost entirely insoluble in water and cold alcohol, more soluble in boiling alcohol, and dissolve freely in ether, bisulphide of carbon and light petroleum spirit. The specific gravity of all oils is lower than that of water, generally from 0.91 to 0.93. The oils are generally classified as:

a. Non-drying, containing mostly olein, such as almond, cottonseed, rape, olive, corn and lard oil;

b. Drying oils, containing linolein, such as linseed, poppy and hemp oils.

The drying oils absorb oxygen from the air and become solid;

the non-drying oils also undergo changes when exposed to air, in that part of the fatty acids are set free, this being the cause of their becoming rancid.

2. ESSENTIAL OILS.

The essential or volatile oils are, with few exceptions, obtained from plants, in which they are found either alone or mixed with resins, this mixture being called a balsam. By adding water to the plant, or part of the plant, and distilling, the oil is carried over with the steam. The turbid distillate separates gradually into oil and water. The volatile oils differ in composition from the fatty oils. Many of them, as for instance, oil of turpentine, are composed of carbon and hydrogen only, while others, like hop-oil and "wintergreen oil," also contain oxygen. Most of these oils, when pure, are colorless, and usually possess a powerful odor and a burning taste. Exposed to air, some absorb oxygen and change into solid resins, as, for instance, "hop-oil," which when it resinifies, develops valerianic acid, producing the disagreeable odor characteristic to old hops. The essential oils are nearly all insoluble or sparingly soluble in water, but soluble in alcohol, ether, fatty and mineral oils. Most of these oils are thin liquids, but some, such as oil of roses or attar of roses, are solids. Essential oils are used in perfumery, for flavoring liquors and other beverages. The aroma of spices, tea, coffee, wine, etc., depends greatly on the essential oils they contain.

One of the most important of the volatile oils is the "oil of turpentine," which is contained in the bark and other parts of pines and firs, and coniferous trees generally. It is obtained by distillation of crude turpentine, which is a mixture of resin, oil of turpentine and water, exuding from the bark of the trees. Oil of turpentine is a colorless, mobile liquid, with a strong aromatic odor. Being a solvent of fixed oil and resins it is largely used for making varnish.

3. HYDROCARBONS OR MINERAL OILS.

The hydrocarbons are composed exclusively of carbon and hydrogen, and are found mainly in crude "petroleum" and coal tar. The mineral oils used for illuminating purposes and as lubricants are chiefly obtained from crude petroleum. Crude *petroleum is a natural* oil, found in the earth at varying depths *in many localities.* The chief sources are located in the United

States and in the Caucasus, on the shore of the Caspian Sea. Crude petroleum is an oily liquid, the specific gravity of which varies from 0.73 to 0.97, of a peculiar odor, and varying in color from straw yellow to brown-black. It is insoluble in water, slightly soluble in alcohol, and mixes in all proportions with ether, bisulphide of carbon and hydrocarbons. It also mixes freely with nearly all fixed oils. Chemically it is a mixture of a number of various hydrocarbons, some of which are gases at ordinary temperatures, others fluids or solids. The different proportions of these various hydrocarbons determine the character of the natural oil, it being more or less limpid, according to the prevalence of light fluids or of the denser constituents. By careful distillation of the natural oil, the different commercial products are obtained. (For particulars see "Lubricants.")

BALSAMS AND RESINS.

Balsams are found in many plants, and are mixtures of rosins with volatile oils (essential oils) and some water. The most common is the balsam that flows from pine-trees, and is generally called turpentine. This is a mixture of oil of turpentine, a little water, and common "rosin" or "colophony." When heated, the oil of turpentine and water are expelled, and the remaining melted mass is the colophony or rosin.

Common rosin still contains some water and volatile oil. This common rosin, or colophony, mixed with some oil to make it less brittle, is "brewers' pitch."

"Shellac" is obtained in a similar way from East India fig-trees. Dissolved in alcohol, it forms common varnish.

"Hop-Balsam" or lupulin consists of the volatile oil of hops and hop-rosin. The oil gives to the beer aroma and flavor, the hop-rosin imparts the bitter taste and helps preserve the beer. Hop-oil is only slightly soluble in water, but freely so in dilute alcohol. Hop-resin is somewhat soluble in water, and more so in a sugar solution.

GELATIN AND ISINGLASS.

Animal membranes, skin, tendons and bones, if heated with water at a high temperature, dissolve more or less completely, and the solutions, when cooled, acquire a soft-solid consistency. These substances may be cut and dried, yielding thus the sub-nce known as gelatin, produced by the action of the hot water

on the tissues. The jelly made from calves' feet and common glue are samples of gelatin, in different states of purity.

Isinglass is prepared from the swimming bladders of fish, principally the sturgeon, or from the same material as gelatin; by a special treatment.

A solution of gelatin, even if very much diluted, gives a precipitate with tannic acid. This precipitate is white, curdy, and incapable of putrefaction, whereas gelatin itself, being composed of the same elements as the albuminoids, easily undergoes changes when not in a dry state.

Vegetable gelatin is similar in composition to the dextrins. It does not dissolve in cold water, but swells up and forms a jelly. It is found in Irish moss, Iceland moss, etc.

CARBOHYDRATES.

The carbohydrates are substances composed of carbon, oxygen and hydrogen, having an equal ratio of oxygen and hydrogen as water; that is, twice as many atoms of hydrogen as of oxygen.

While they are made up of the same elements as the alcohols and acids, their molecules are much larger. The molecule of starch, for instance, has the composition $C_{18}H_{30}O_{15}$, or contains 63 atoms; maltose is $C_{12}H_{22}O_{11}$, glucose $C_6H_{12}O_6$, etc. They are, therefore, easily split up into simpler molecules, and give rise to such substances as carbonic acid, different kinds of organic acids, and alcohol. Upon being heated with dilute acids, such as hydrochloric or sulphuric, they are all changed into that type of sugar which is generally called grape sugar or dextrose.

CELLULOSE.

The walls of all plant cells are composed of cellulose, and a large portion of the solid parts of all plants is built out of this substance.

Pure cellulose is tasteless and insoluble in water and alcohol. Even boiling dilute acids and alkalies have but little effect on cellulose. Upon being boiled for some time with strong acids it is transformed completely into grape-sugar. The husk of the malt is mainly composed of cellulose which serves to strain the wort when it is run off (brewers' grains). Cellulose is not colored blue *by iodine.*

STARCH, DEXTRIN AND SUGARS.

Starch is a most important vegetable product, and present, to a greater or less extent, in every plant, especially in the seeds. It is insoluble in cold water and alcohol; it is tasteless and odorless. The relative amounts of carbon, oxygen and hydrogen it contains are the same as in cellulose. To the naked eye it appears as a soft, white, glistening powder; under the microscope it is seen to be made up of small rounded bodies. These starch granules vary both in form and size in the different varieties of starch.

If a mixture of starch and water is heated, the starch granules burst and disappear at a certain temperature, and a transparent paste is produced. This change takes place at different temperatures in the different types.

Starch consists of two parts evenly distributed through the granule. One part, which may be said to be the skeleton of the granule, is called starch-cellulose, the other, starch-granulose. If starch in water is heated for some time with dilute acids or a solution of diastase, the granulose is converted into sugar and dextrin, but the starch-cellulose is left unchanged. The percentage of starch-cellulose is very small.

IODINE AND STARCH.

If a solution of iodine in iodide of potassium is admixed to starch paste, a deep blue compound results. The presence of unconverted starch in a mash or wort can, therefore, be detected by means of the iodine solution. The starch solution must, however, be cold, as heat dispels the blue color.

Glycogen or animal starch is found in the livers of mammals. It forms a paste with cold water and dissolves when heated. Boiling acids change it to grape-sugar. Iodine solution gives it a reddish-brown color.

DEXTRINS.

If a starch-paste is heated for some time under pressure with a small quantity of a dilute acid, for instance, sulphuric or hydrochloric, the starch paste will soon lose its consistency and turn thin. There has taken place a modification of the starch into a substance called dextrin, which is a gum-like mass, soluble in *water and has an equal* percentage of carbon, oxygen and hydrogen *as starch.*

The time required for this change depends on the amount of acid. If the mass be kept at a boil for a considerable time, the dextrin is gradually changed to grape-sugar, or dextrose.

Gallisin, which may be compared to malto-dextrin, is also formed.

Diastase effects a similar change in a starch paste, splitting the starch-molecule into simpler molecules of different kinds of dextrins and sugars.

About the number and composition of these split-products of starch, the opinions of the chemists disagree, which is explained by the difficulty of producing the various decomposition-products in a pure state.

According to Brown and Morris the starch is gradually changed into several varieties of dextrin, such as:

1. *Amylo-dextrin,* which in its properties shows close relationship to starch and is colored blue or violet-blue by iodine;
2. *Erythro-dextrin,* which is colored red by iodine;
3. *Achroo-dextrin,* which is not colored by iodine;
4. *Malto-dextrin;*
5. *Maltose.*

The three first-named dextrins are supposed to be unfermentable, malto-dextrin and maltose fermentable. Maltose ferments rapidly during the principal fermentation, malto-dextrin slowly during after-fermentation, and the more completely, the nearer the composition of the malto-dextrin comes to that of maltose.

Another theory of the decomposition of starch by diastase is proposed by Lintner and Düll. According to their view the starch is transformed into four dextrins, viz.: *Amylo-dextrin, Erythro-dextrin, Achroo-dextrin I, Achroo-dextrin II,* and two sugars, *isomaltose* and *maltose.*

Prior claims that the achroo-dextrin III, found by him, is the dextrin that remains in the beer.

As to the two different theories the most generally accepted one is that of Brown and Morris. Later experiments by Ling and Baker, Brown and Morris, Jalowetz and Ost show that isomaltose is not homogeneous, but a mixture of maltose and dextrins, and *that maltose is the only* sugar formed by the action of diastase on *starch.*

SUGARS.

The chemical composition of the different types of sugar is similar to that of cellulose and dextrin. The most noteworthy properties of the sugars are: Their sweet taste, ability to undergo fermentation, solubility in water and alcohol, and facility of crystallization.

DEXTROSE.

This sugar, also called glucose, grape—or starch sugar, is very common in many plants, as in the juice of sweet grapes. It also occurs in honey and in many animal liquids, as blood, and, pathologically, in urine.

Artificially it is made from starch by heating with dilute sulphuric or hydrochloric acid until the dextrin, which is the first product of the action of the acid on the starch, is changed into sugar. The commercial products of the conversion of starch, as glucose (syrup) and grape-sugars (solid) contain varying quantities of dextrin, dextrose and water.

Dextrose is not so sweet as cane sugar and is directly fermentable. If yeast is introduced into a solution of grape-sugar in water, the sugar is split up into nearly equal quantities of alcohol and carbonic acid. This change is expressed by the following chemical formula:

$$C_6H_{12}O_6 = 2\ (C_2H_6O) + 2\ CO_2.$$

Grape-sugar = 2 alcohol + 2 carbonic acid.

or, by weight, 180 parts of sugar $(6 \times 12 + 12 \times 1 + 6 \times 16 = 180)$, give 92 parts of alcohol $[2\ (2 \times 12 + 6 \times 1 + 16) = 92]$, and 88 parts of carbonic acid gas $[2\ (12 + 2 \times 16) = 88]$. Hence, 100 parts of sugar produce 51.1 parts of alcohol and 48.9 parts of carbonic acid. The amounts of alcohol and carbonic acid are not quite up to these figures for the reason that small quantities of glycerin and succinic acid are formed by the action of the yeast on the sugar.

FRUCTOSE, OR FRUIT SUGAR.

This sugar, also called levulose, is found in most sweet fruits mixed with an equal amount of grape-sugar. It is supposed to be *formed by the breaking* up of the cane sugar of the plant into *grape-sugar and fruit*-sugar, the mixture of the two being called *invert sugar*. *Fruit*-sugar is also found in malt in small quan-

tities. It closely resembles grape-sugar, but crystallizes only with difficulty from cold absolute alcohol, and is slightly more soluble in water, and ferments more slowly than grape-sugar.

GALACTOSE.

This sugar is formed together with grape-sugar when lactose or milk sugar is treated with dilute acids. It ferments slowly (Koumiss).

SACCHAROSE, OR CANE-SUGAR.

This sugar is found in the juice of the sugar cane, in the stems of sorghum, in the sugar beet, in the sap of trees, as the maple, and in many other plants and fruits. It is a product of a chemical change in the starch of the plants. If a solution of cane-sugar in water is slowly evaporated, the sugar crystallizes in large, transparent crystals (rock candy). If a hot concentrated sugar solution is cooled, it changes into a solid mass of fine crystals (loaf-sugar). Cane-sugar is very soluble in water; the concentrated solutions are called syrups. A concentrated solution at ordinary temperature holds over 66 per cent of cane-sugar. Cane-sugar melts at a temperature of (about) 320° F. At a still higher temperature it takes a brown color, and in that state is used for coloring liquors ("Sugar Color," "Caramel").

Cane-sugar is not directly fermentable, but, when boiled with dilute acids, changes into a fermentable sugar called invert sugar, which is a mixture of grape-sugar and fruit sugar. A ferment contained in yeast and called "invertase" also has the power to change cane-sugar into invert sugar.

MALTOSE.

If ground malt is mixed with water and kept at a temperature of 100° F. to 167° F., the diastase of the malt slowly changes the starch into dextrin, and a kind of sugar called maltose. When freed from the dextrin it can be crystallized in white needles. It resembles grape-sugar in many respects, but is not directly fermentable. A substance contained in the yeast, and called maltase, changes it into grape-sugar. Maltose is also changed into grape-sugar by heating with dilute acids.

LACTOSE, OR MILK-SUGAR.

This sugar is found in milk, the nutritive value of which partl *depends upon this* sugar. It forms small, hard crystals, whi

are not very soluble in water, nor very sweet. It is not fermented by yeast, but under the action of lactic bacteria it is changed into lactic-acid (souring of milk). Dilute acids change lactose into grape-sugar and galactose. Milk sugar is used in pharmaceutical preparations.

RAFFINOSE, OR MELITOSE.

This sugar is found in rather large quantities in Australian manna, in the sugar beet, the flour of cotton seeds, and in barley and wheat during germination. Being more soluble than cane sugar, it accumulates in the molasses. Dilute acids split it up into grape-sugar, fruit-sugar and galactose. Yeast is also able to produce this change and consequently raffinose is fermentable.

ARABINOSE.

This sugar is a member of the group called penta-glucoses or pentoses, because their molecules contain only five carbon atoms. Thus the formula of arabinose is $C_5H_{10}O_5$.

Arabinose crystallizes in shining prisms, is slightly soluble in cold water, and has a sweet taste, though less than that of cane-sugar. It is not fermented by yeast.

PECTIN SUBSTANCES.

These substances are closely related to the carbohydrates, though of much less importance. They are found, for instance, in apple and pear-juice. The juice is boiled and filtered from coagulated albumen; to the clear filtrate is added a mixture of alcohol and hydrochloric acid, which causes a jelly-like precipitate of pectin. Similar bodies are also found in barley, malt and beer, the viscosity, palate-fulness and foam-holding capacity of which was formerly largely ascribed to these substances, and some authors still claim that excessive clarification of beers by fining or filtration tends to impair these valuable properties of beer on account of the removal of these pectins

TORREFACTION OR ROASTING PRODUCTS.

Carbohydrates and, still more, albuminoids are characterized by their large and complicated molecules which are easily decomposed. That a high temperature will produce changes in these substances is, therefore, to be expected. In the presence of moisture these changes begin at a much lower temperature than in the absence of moisture, i. e., if the carbohydrates and albu-

minoids are previously dried almost completely at a low temperature.

If malt with a certain amount of moisture is heated to from 140° F. to 160° F., it begins to emit a peculiar, agreeable aroma and, at the same time, the starch-body acquires a darker color.

In order to produce a fine aroma the malt must, however, have grown enough, i. e., it must have a sufficient amount of diastatic power, which produces sugars in the presence of moisture at certain temperatures. Without these sugars even a higher temperature will not produce an agreeable flavor.

The bodies produced from sugars (especially from malto-dextrin) at higher temperatures, are generally called *caramel.* If the temperature goes higher, the caramel gives rise to a substance called *assamar,* which has a bitter taste. At a still higher temperature the sugar, and, finally, the starch itself, begins to char.

Another body that has been isolated from caramelized malt is *maltol* which, with ferric chloride solution, gives a purple color similar to that produced by salicylic acid in a ferric chloride solution.

If cane-sugar is heated to 320° F. it melts, and if the temperature is raised to 390° F., it changes to a brown syrupy mass, soluble in water, but not crystallizable. It contains caramel and assamar, and has no sweet taste. It finds application in coloring fluids called "Sugar Color," or "Beer Color."

NITROGENOUS ORGANIC COMPOUNDS.—ALBUMINOIDS.

The albuminoids (so-called from albumen, the white of egg), which are composed of carbon, oxygen, hydrogen and nitrogen, and a small amount of sulphur, are the principal constitutents of the animal organism. They are produced, however, exclusively by the plants, and found chiefly in their seeds. When absorbed into the animal organism, the albuminoids undergo a very slight modification, so that animal albuminoids have very much the same composition as vegetable. They possess a very complex constitution, the molecule of albumen, according to Lieberkühn, being $C_{72}H_{112}N_{18}O_{22}S$. Hence, their molecules readily fall into simpler molecules. This process, when brought about by bacteria, *is accompanied by the* generation of gases, like carbonic acid, *ammonia, and sulphuretted* hydrogen, and is termed putrefaction.

Of the vegetable albuminoids some are soluble in water, others are insoluble.

The insoluble and soluble albuminoids of the grain have been the subject of many researches with very discordant results. Of the different varieties of insoluble albuminoids may be mentioned gluten-casein, gluten-fibrin, gliadin and mucedin.

The albuminoids of the malted grain, which are the most important and most interesting to the brewer, are extracted from the crushed malted cereal during the mashing process. Simultaneously with the solvent action of the water an enzyme called peptase contained in the malt acts upon the albuminoids, gradually changing them in a manner somewhat similar to the action of diastase upon starch.

The products of the action of peptase upon the albuminoids of malted grain are generally referred to four distinct groups, with different properties. The first group is called proteids.

PROTEIDS.

The proteids include all such soluble albuminoids as become insoluble or, as it is called, coagulate, at a temperature above 167° F. An example of this is seen in the "break" of the wort during boiling. The proteids which remained in solution at the lower temperature of the mash, settle or coagulate as flakes in the kettle at boiling temperature, and are, therefore, almost completely removed from the wort. A very low temperature also causes the proteids to become insoluble. They are insoluble in alcohol, and tannic acid precipitates them from a solution.

ALBUMOSES.

The second group of soluble albuminoids is called albumoses. They are formed by the action of peptase upon the albuminoids during the germination and mashing processes. The albumoses are not coagulated by heating their solution and, consequently, remain in the wort, and as they are not fermented by the yeast, pass over into the finished beer. Like the proteids, they are precipitated by tannic acid, and are insoluble in alcohol.

PEPTONES.

The third group of soluble albuminoids is called peptones. They are products of the continued decomposition of the albuminoids of malted grain, under the influence of peptase. They

are not coagulated by heat and are therefore present in the finished wort. During fermentation they are, to a small extent, fermented by the yeast, but the greater part of the peptones enter into the finished beer.

They are precipitated by tannic acid and insoluble in alcohol.

AMIDES.

The fourth group of soluble albuminoids is called amides. They are of much simpler composition than the albumoses and peptones. They are not coagulated by heat, nor can they be precipitated by tannic acid or alcohol.

The amides are to some extent taken up by the yeast and, therefore, partly withdrawn from the beer.

The albumoses, peptones and amides are of the greatest value for the beer. Not only do they serve as a nourishment, but the palate-fulness and foam-holding capacity of the beer, as was first conclusively shown by the exhaustive investigations of Wahl, depend mainly on these bodies. The proteids, on the other hand, are very undesirable constituents of beer, impairing, when present even in small quantities, the brilliancy and durability of beers.

ENZYMES, OR SOLUBLE FERMENTS.

A large number of substances are found, both in the animal and in the vegetable kingdom, which possess the remarkable property of changing complicated organic combinations in the presence of water into simpler ones without undergoing any appreciable change themselves. Such substances are designated by the name of enzymes. In chemical composition they are similar to the albuminoids, of which they appear to be slight modifications. They are easily soluble in water. All of them have certain limits of temperature, outside which they do not act. A temperature of 167° F. destroys them, when in solution, the heat causing them to coagulate. In a perfectly dry state they may be heated to 212° F. and above, without losing their power. Alcohol precipitates them from their solutions. The most important enzymes are the following:

DIASTASE.

This peculiar substance, which consists of carbon, hydrogen, oxygen *and nitrogen*, occurs in germinating seeds. Upon coming *in contact with starch* at a temperature of 100° F. to 167° F., it

quickly changes the starch into dextrin and sugar. It is this change of the starch into products soluble in water that constitutes the conversion of the starch in the mashing process. The change of the starch is brought about without any change in the diastase, so that a small quantity of diastase is capable of changing a large amount of starch.

By its mere presence, diastase causes the starch of malt to take up water, whereupon the starch molecule is split up into dextrin and a sugar called maltose. The chemical formula for this change is:

$$C_{18}H_{30}O_{15} + H_2O = C_{12}H_{22}O_{11} + C_6H_{10}O_5.$$

Starch + Water = Maltose + Dextrin.

Heating to 167° F. destroys the diastase.

GLYCASE.

This enzyme was found by Kjeldahl in ungerminated barley. It differs from diastase in its action on starch in two respects. It acts only on soluble starch, whereas diastase will act on starch paste and make it fluid; and secondly, the sugar formed by glycase is dextrose and not maltose.

CYTASE.

This enzyme has the power of dissolving the cellulose of the cell-walls of the starch granules and thus liberating the starch and furnishing nutritive material for the young plant.

It is extracted with cold water from green malt. Raw oats contain it in still larger quantities.

It is more sensitive to heat than diastase, being destroyed at a temperature of 140° F. to 150° F.

INVERTASE.

This is the best known enzyme of the yeast. It can be extracted from dried yeast with water, precipitated with alcohol, and dried over sulphuric acid. Thus made it is a white powder. It has the power of changing the unfermentable cane-sugar into fermentable dextrose and fructose, the mixture of which is called invert-sugar.

Invertase does not act upon maltose.

MALTASE (GLUCASE).

It was long supposed that maltose was a directly fermentable sugar. Later investigations by Lintner have proved, however, that

the maltose molecule is split up into two molecules of dextrose by an enzyme contained in yeast, and to which the name maltase or glucase has been given. It is extracted by water from air-dried yeast. High attenuating types of yeast are claimed by some authorities to contain an enzyme (glucase), which is not present in low attenuating types. This glucase is supposed to have the power of inverting malto-dextrin to maltose or dextrose, hence the higher fermenting power of such yeasts.

ZYMASE.

This enzyme has only lately been found in yeast by Buchner, and has the property of producing alcoholic fermentation, i. e., decomposing sugar into alcohol and carbonic acid, independently of the yeast cells. Its action is not inhibited by many substances, for instance, chloroform, which prevent fermentation by yeast itself. On the other hand, such by-products as glycerin and succinic acid, which are produced during fermentation by yeast, do not seem to accompany fermentation by zymase.

A solution of zymase in water begins to coagulate when heated to 95° F. to 100° F., and after separating the coagulum, the extract has no further fermentative power.

PEPTASE.

This enzyme which is contained in malt has not yet been isolated. It acts upon the albuminoids of malted grain, changing them into soluble proteids, peptones and amides. Its action is promoted by the presence of a small amount of lactic acid. According to Wahl and Nilson, it is most active at a temperature of 100° F. to 130° F., and is destroyed at 156° F.

PTYALIN.

This enzyme is found in the saliva of animals and may be identical with diastase.

PEPSIN.

This enzyme was found as early as 1836 by Schwann in gastric juice, and he also demonstrated its capacity of changing indiffusible albuminoids into simpler forms, capable of passing through the animal membranes.

The enzyme is contained in glands of the mucous membrane of the stomach of the vertebrate animals, and is also found in the blood, muscles, and urine of the higher animals. Pepsin is active

only in the presence of a small amount of hydrochloric acid, and this acid is found in gastric juice to an amount of 0.2 to 0.5 per cent. Heating to 130° F. to 135° F. destroys pepsin. The pepsin of commerce is a crude product.

TRYPSIN.

This enzyme is found in the pancreatic secretion of the higher animals. Its action does not depend on the presence of an acid; on the contrary, it acts best in an alkaline solution, for instance, in the presence of carbonate of soda. It decomposes the albuminoids farther than pepsin, changing them even so far as to produce crystallizable amides.

EMULSIN.

This enzyme is found in the bitter almond. It acts upon a group of bodies called glucosides which are esters of sugars with organic acids. Under the influence of emulsin they are split up into simpler substances among which dextrose is always found.

DIASTASE AND STARCH.

HISTORICAL REVIEW.

Previous to 1860 it was supposed that dextrin was the first product resulting from the action of diastase on gelatinized starch, and that dextrin was then converted into sugar, the starch molecule uniting with a molecule of water according to the following formula:

$$\underset{\text{Starch.}}{C_6 H_{10} O_5} + \underset{\text{Water.}}{H_2 O} = \underset{\text{Sugar.}}{C_6 H_{12} O_6}$$

The process of taking up water is termed "hydration." The products of hydration weigh more than the substances forming them. Ninety parts of starch, for instance, will furnish 100 parts of sugar (dextrose).

In 1860 Musculus advanced the theory (Annalen der Chemie und Physik, 55, page 203) that dextrin is not an intermediary product between starch and sugar, but that dextrin and sugar are produced from starch simultaneously, either through the action of acids or diastase. This theory found general acceptance among chemists.

In 1870 Schwartzer found (Journal für Practische Chemie) that *the temperature at* which inversion of starch into sugar takes *place is of considerable* influence in determining the relative pro-

portion of sugar and dextrin produced, and that consequently the chemical process of inversion did not always proceed as Musculus supposed, according to the formula:

$$3C_6H_{10}O_5 + 2H_2O = 2C_6H_{12}O_6 + C_6H_{10}O_5$$

Starch. Water. Sugar. Dextrin.

In 1871 Griessmayer discovered that among the products of hydration of starch are present two kinds of dextrin. A year later Brucker named one of these variations of dextrins "erythro-dextrin" (red dextrin), and the other "achroo-dextrin" (colorless dextrin), the first having the property of being colored red by iodine, while the second remains colorless.

In 1872, O'Sullivan, while engaged in the study of the action of fresh malt extract on the dextrins just mentioned, found that the sugar formed is not dextrose, as had been supposed up to that time, but another sugar, isolated first by De Saussure, as early as 1819, from the products of hydration of starch, but named "maltose" by Dubrunfaunt only in 1847. O'Sullivan was the first who informed us of the influence of temperature, time and concentration on the relative amounts of maltose and dextrin resulting from the action of malt extract on starch. According to O'Sullivan's investigation the relative proportion of maltose to dextrin is much higher in case inversion takes place at a temperature below 145° F., than at about 155° F.

In 1878 Musculus and Gruber expressed the opinion that the starch molecule is disintegrated by the action of diastase in successive stages. First a molecule of maltose and a molecule of a dextrin are formed, having a molecular weight nearly as high as starch. This dextrin is in its turn split up into maltose and dextrin of lower molecular weight, until a dextrin is formed on which diastase does not act under usual conditions.

In 1879 Brown and Heron made valuable contributions to our knowledge of the action of diastase on starch. They found, first, that diastase has no effect on unruptured potato starch; secondly, that when starch was ground in a mortar with quartz, sand, etc., it was slowly transformed by diastase into maltose and dextrin at a low temperature; thirdly, that gelatinized starch is quickly liquefied in the cold, and slowly transformed into maltose and dextrin; fourthly, that the action of malt extract, after heating, was materially changed as to its power of inversion, but not as to its power of liquefying starch; fifthly, that the relative

amounts of maltose and dextrin formed below 140° F. were about the same, while at temperatures above 140° F. the relative amount of maltose decreased and that of dextrin increased; sixthly, that at higher temperatures, dextrins are formed that are, as far as their molecular structure is concerned (erythro-dextrin), closer to starch than those formed at lower temperatures (achroo-dextrins); seventhly, that the action of diastase is much retarded in alkaline solutions, while erythro-dextrin is formed at the same time.

The experiments of Brown and Heron, besides being of great practical interest, enabled them to formulate a theory which coincided with that expressed by Musculus and Gruber. They regard soluble starch as a complex of 10 groups of $C_{12}H_{20}O_{10}$. By the action of diastase one of these groups unites with water, forming maltose, while the remaining nine are left as erythro-dextrin. This, in turn, loses one of its $C_{12}H_{20}O_{10}$ groups by combination with water, forming maltose and leaving a dextrin with eight $C_{12}H_{20}O_{10}$ groups, etc. Brown and Heron assume, therefore, the existence of nine different dextrins, which goes to illustrate the exceedingly complex nature of the process of the breaking down of the starch molecules.

In 1879 Hertzfeld (Inaugural Dissertation, Halle) found in the products of starch hydration a body which he described as being intermediate between achroo-dextrin and maltose, and which he termed malto-dextrin. He assumed that it was composed of two molecules of dextrin and one of dextrose.

The results of a number of experiments made by Brown and Morris, and communicated in 1885 (Journal Chemical Society, 1885, page 527), and later (Trans. Lab. Club III, 4, 1890. Brewing Trade Review, 1895) led them to enunciate the so-called malto-dextrin or amyloin theory of the hydration of starch by diastase. They view the starch molecule as composed of five dextrin molecules, four of which are grouped around a central dextrin molecule. When acted upon by diastase the four groups are readily split off and hydrated, yielding besides maltose a number of malto-dextrins, that is, bodies containing dextrin and maltose in varying proportions, while the centrally grouped mole*cule of dextrin* is stable, that is, it undergoes hydration only with *extreme difficulty*. The chemical equation for this process is the *following:*

$$\underset{\substack{\text{Starch}\\ \text{molecule.}}}{5\ (C_{12}H_{20}O_{10})_{20}} = \underset{\substack{\text{Stable}\\ \text{dextrin.}}}{(C_{12}H_{20}O_{10})_{20}} + \underset{\substack{\text{Subject to}\\ \text{hydration.}}}{4\ (C_{12}H_{20}O_{10})_{20}}$$

The four dextrin groups take up water readily under the influence of diastase, yielding first malto-dextrins with a high amount of dextrin and low amount of maltose; this, in turn, being hydrated to malto-dextrins with ever decreasing amounts of dextrin and increasing amounts of maltose, until finally maltose is reached. The first malto-dextrin formed would have one maltose molecule and nineteen dextrin molecules, the second two maltose molecules and eighteen dextrin molecules, the last one nineteen maltose molecules and one dextrin molecule.

According to Brown and Morris these amyloins or malto-dextrins are well defined chemical substances that are changed by the action of diastase into maltose, and are but slowly fermentable, but the more readily so, the smaller the number of dextrin groups and the larger the number of maltose groups they contain, that is, the closer they approach in composition pure maltose. In practice, the malto-dextrins remain intact during the principal fermentation, but are gradually split up during the secondary fermentation, which, in the case of top-fermenting beers, like stock ale and stout, is carried out by wild yeasts.

According to Lintner and Düll (Berichte der deutschen Chem. Gesellschaft, 1893, page 2,533), diastase splits up starch into the following six bodies: Amylo-dextrin (blue color with iodine), erythro-dextrin (red color with iodine), achroo-dextrin (no color with iodine) I and II, isomaltose, and maltose. According to their view maltose is evolved at once out of starch and not through the successive stages of dextrins and malto-dextrin. During the principal fermentation the maltose ferments, while during the secondary fermentation isomaltose, together with achroo-dextrins I and II, slowly ferment, being gradually changed to maltose and dextrose by an enzyme contained in the yeast (yeast maltase).

Prior (Bayerisches Brauerjournal, 1896, page 157) discovered another dextrin which he calls achroo-dextrin III, and considers to be practically unfermentable, and the one which remains in the beer. Prior's view is that the maltose, saccharose, dextrose and levulose contained in the beer, are all readily fermentable and only small quantities remain after the principal fermentation.

while isomaltose and the achroo-dextrins I and II remain practically intact during the principal fermentation, but are gradually hydrated, changed to dextrose, and fermented during the secondary fermentation, achroo-dextrin III alone resisting the attack of the yeast. A similar view was also expressed by Krieger about simultaneously with Prior.

The theories of Brown and Morris and Lintner have not as yet become reconciled, and there are observers, basing their views on original work, who dispute the validity of both, for instance, Scheibler and Mittelmaier (Berichte der deutschen Chem. Gesellschaft, 1893, page 2,930), and Ost (Chemikerztg., 1895, page 1,501). Be this as it may, practical brewing operations may be understood and explained by either hypothesis, although as far as top-fermenting beverages, like stock ale and stout, are concerned, it seems as if the phenomena and the results of the methods of mashing, as well as of those of the subsequent treatment of beer, called for the existence of malto-dextrins in explanation.

PEPTASE AND ALBUMEN.

HISTORICAL REVIEW.

The inquiry into the interaction between peptase and the albumen of barley or malt has not yet furnished so satisfactory results as that relative to diastase and starch. This interaction seems to be of a still more complex nature than in the case of diastase, a large number of different products resulting, most of which still await characterization. On account of the difficulty of their isolation and their evanescent nature these products have not received the attention of observers in the science of brewing that their importance as desirable or undesirable constituents of the beer seems to merit. There consequently still remains much diversity of opinion regarding proteolytic action, as the hydration of albumen by enzymes is termed, while some investigators have gone so far as altogether to dispute the very existence of any proteolytic enzyme (peptase) in barley or malt.

Since peptase has not yet been isolated, the process of hydration or peptonization by peptase must still be regarded as an hypothetical one. So many products are known to be formed, however, during the germination and mashing processes, that are very *similar to, if not identical* with, those which result from the *action of the enzymes like* pepsin and trypsin on animal albu-

men under similar conditions, that the existence of a vegetable enzyme in barley and malt has all along been considered most probable.

The nomenclature adopted for the animal albumens and the products obtained by the action of the animal enzymes, pepsin and trypsin, on them, has, on account of this general similarity, been extended to the vegetable albumens and the products of the action of the hypothetical vegetable enzyme—peptase. Thus we have animal and vegetable albumen, animal and vegetable proteids, animal and vegetable albumoses or proteoses (as albumoses are also called), animal and vegetable peptones, animal and vegetable amides. That the vegetable albuminoids (this term comprises albumen and all nitrogenous bodies derived therefrom) must in every particular be identical with those of animal origin is, however, improbable, considering their very complex nature. So we need not be surprised to find some of the reactions that characterize animal nitrogenous bodies fail when applied to the vegetable substances, as has been shown to be the case of late by Lascynski and H. Loe, who found that certain tests which are used to detect the presence of animal peptones, when applied to wort, give negative results. That conclusions in this field of research should be made only with great caution is proved by the fact that soon after these observers had expressed the view based upon their investigations, that peptase did not exist, Windisch proved conclusively that germinating barley does develop a proteolytic enzyme (peptase), although he has up to this writing not yet made communication of its isolation.

Until it has been isolated and its action upon vegetable albumen studied, we can only infer what the process may be like, by studying the known action of the animal enzymes, pepsin and trypsin. If an egg is boiled hard, the white of it cut up in small parts and grated through a sieve and placed in water containing 0.2 per cent of hydrochloric acid and a very small amount of pepsin added, and this mixture kept at 100° F. (30° R.) for a few hours, most of the albumen will be found dissolved, and the filtrate may be heated to 190° F. (70° R.) without producing coagulation. If heated above 190° F. (70° R.) to boiling point, or neutralized, a coagulate forms which is composed of syntonin, corresponding probably to the brewer's coagulable proteids. Of the albuminoids remaining in solution, part are precipitated if the solution is sat-

urated with ammonium sulphate. The precipitated albuminoids are known as proteoses or albumoses, while the substances that remain in solution after saturation with ammonium sulphate are called peptones.

The peptones are not acted upon any further by pepsin, but yield readily to the influence of another animal enzyme, trypsin, which changes the peptones into amides. Since germinated barley and wort contain large quantities of amides, as the composition of malt and wort shows, this indicates that there is quite an energetic proteolytic enzyme contained in malt which carries the breaking up of the albumen to a farther stage than even pepsin is capable of doing. These various products, like proteids, albumoses, peptones and amides, are not well defined characteristic bodies like maltose and dextrose, but each name comprises a group of more or less numerous bodies, each group being characterized by a similar behavior of each of its members toward certain reagents and under certain conditions, just as is the case with certain products of starch hydration, like the members of the group dextrin, which are characterized as unfermentable, or the members of the sugar group, which are characterized as fermentable.

As to the practical importance of these different albuminoids during the process of brewing and as constituents of the finished beer, little was known before the last decade. With the exception of the amides, which were regarded as valuable as furnishing the nitrogenous nutriment required by the yeast, the albuminoids as a body were supposed to exert a detrimental influence on the properties of beer, impairing its brilliancy and durability, and the English brewing chemists of to-day still hold the opinion that the aim of the brewer should be to reduce the amount of albuminoids of the wort to a minimum.

In 1893 (American Brewers' Review, 1893, Vol. VII, pages 185 and 201) R. Wahl read a paper before the United States Brewmasters' Association, to claim attention for the importance of the albuminoids of the beer, showing that some of them, like proteids (those which are rendered insoluble by high or very low temperatures) may become obnoxious, but others, like the peptones, are conducive to palate-fulness and foam-holding capacity, while the amides had long since been recognized as serving as nourishment for the yeast. Wahl's claim as to the value of the

peptones was based on the simple experiment of preparing solutions of dextrin and sugars in different amounts as well as solutions of peptones obtainable in the market, charging these solutions with carbonic acid gas, cooling and pouring into a glass, when it was found that the solutions containing only 0.5 and 0.2 per cent of peptones had a more creamy head of foam than the solution with either 5 or 3 per cent of dextrin or sugar, while the solution of 0.5 per cent of peptone was as full to the taste as the one containing 5 per cent of dextrin. Thus was established for the first time the fact that peptones have a much greater effect in giving palate-fulness to the beer than either sugar or dextrin, which latter substance had up to that time been supposed by all observers to be principally concerned in imparting foam-holding capacity and palate-fulness.

In 1894 (American Brewers' Review, 1894, Vol. VII, page 519), Wahl and Nilson published the results of elaborate researches regarding the nature and importance of the albuminoids of beer.

In this investigation the current division of the albuminoids into proteids, peptones and amides was accepted, the peptones including the albumoses. By proteids were meant those albuminoids which are easily precipitated in wort or beer by such processes as boiling, storage at low temperature and pasteurization, and can be analytically determined by precipitation with cupric hydroxide or acetate of lead. The peptones include those substances which are not precipitable by cupric hydroxide, but are precipitated by phosphoro-tungstic acid or tannin, the remaining nitrogenous bodies being classed as amides.

The following results were obtained (American Brewers' Review, Vol. VII, page 580):

1. In different malt mashes held for an hour and a half at 68, 77, 86, 100, 104, 113, 131, 149, 158, 167° F. (16, 20, 24, 30, 32, 36, 44, 52, 56, 60° R.) it was found that the largest amount of total nitrogenous bodies passed into solution at 113° F. (36° R.), but was very nearly the same for all temperatures between 100° and 149° (30-52° R.), while above 149° the amount decreased rapidly with this temperature.

2. If these temperatures were maintained for a longer period (three hours), the amount of total nitrogenous bodies increased *at temperatures below* 149° F. (65° R.), but not above.

3. Mashes conducted at low temperatures, that is, 95-104° F. (28-32° R.), contain a much larger percentage of coagulable albuminoids than mashes made at a higher temperature (from 140-176° F.) (48-64° R.). This accounts for the fact that worts prepared at low initial mashing temperature will break better in boiling. The proteids, moreover, will be more completely removed from the wort by boiling and through storage at low temperatures, and beers with greater stability will result.

4. In two mashes, one of which was produced by stirring malt into eight parts of boiling water and the other in water of 77° F. (20° R.), at which temperature they were kept for two hours, the following amounts of nitrogenous bodies were found in solution:

Temperature	77° F. (20° R.)	212° F. (80° R.)
Albumen	0.467	0.222
Proteids	0.056	.....
Peptones	0.129	0.179
Amides	0.282	0.043
Proteids in per cent of total Albumen	12.2	......
Peptones	27.4	80.6
Amides	60.4	19.4

Taking the albuminoids found after mixing malt with boiling water to represent those pre-existent in the malt, the result shows that the wort contains about double the amount when mashed at as low a temperature as 77° F. (20° R.) and nearly three times the amount when mashed at the temperature most favorable to the action of peptase.

The soluble albuminoids pre-existent in the malt consist, for the greater part, of peptones, while those found in the wort formed during mashing are mostly amides.

5. The concentration of the mash does not exert any appreciable influence upon the amount of the albuminoids contained in the resulting wort within the ratios of malt to water of 1 to 8 and 1 to 2¼. (American Brewers' Review, Vol. VIII, page 641.)

6. The proportion of amides to the total amount of nitrogenous substances remains unchanged for different concentrations and *temperatures.*

7. The amount of nitrogenous bodies taken from the wort during fermentation by the yeast (American Brewers' Review, Vol.

VII, page 72) varied within rather narrow limits (at a high temperature and with powerful aeration), being an average of 30 per cent, independent of the mashing method, the density of wort or the yeast type (high or low fermenting). The loss of nitrogenous bodies was largest in the amide group, and amounted to about 25 per cent of all nitrogenous bodies. It affected the non-amides (peptones, etc.) only to a limited extent, amounting to 2.7 to 4.6, or, on an average, 3.5 of the total nitrogenous bodies.

8. Under the conditions prevailing in low fermentation breweries the loss of nitrogenous bodies occuring during fermentation is found to be very near the same per volume of beer or wort, whether the wort contains much or little nitrogenous matter, and is distributed approximately in equal shares among bodies of the amide group and those of the peptone group.

In 1895 Erich corroborated the results obtained by Wahl and Nilson (Der Bierbrauer, 1895, page 162). He expresses the opinion, based on his experiments, that, as in germination, there goes on in mashing a process of peptonizing of albuminoids, and it must be assumed that this peptonization progresses the further, the longer the mash is kept at a temperature favorable to the operation of peptonizing enzymes.

Hantke, in 1895, published (Brewer and Maltster, 1895, page 1148) investigations practically covering the same field and leading to the same conclusions as Wahl and Nilson, without apparently having any knowledge of the work of those observers, since he took no notice of their publication over a year in advance of his own.

There still remained unanswered the question, which of the nitrogenous constituents of the wort possessed the greater power of producing foam. Windisch (Wochenschrift f. Brauerei, 1893, page 1381) disputed that the peptones had any value in this respect, claiming this property for the albumoses. Windisch founded a new mashing method on this theory (Wochenschrift f. Brauerei, 1896, page 79, 1254, and 1897, No. 3), assuming that higher initial temperatures, like those employed in England, would result in worts with larger percentages of albumoses and hence in beers with the highest degree of foam-holding capacity and palate-fulness, which two properties are generally supposed to go hand in hand.

Krieger rejected the theory of both Wahl and Windisch, and

claimed that the coagulable albuminoids formed during fermentation were responsible for the foam-holding capacity of the beer. (The American Brewer, 1897, page 246.)

In the same year M. Henius and G. Thevenot (American Brewers' Review, Vol. X, page 409 and 410) made two brews in the experiment brewery of the Scientific Station of Chicago, one according to Windisch's method with high initial temperature (156-158° F., 55-56° R.), the other according to Wahl's method with low initial temperature (100° F., 30° R.), holding this temperature one hour, the object being to ascertain which of the two resultant worts and beers contained the largest amount of foam-producing albuminoids. The analysis of the worts showed the following figures:

Amount of Albumen (N x 6.25) in 100 parts of extract.

	Wahl's Process.		Windisch's Process.	
	Wort.	Beer.	Wort.	Beer.
Total Albumen	5.98	5.03	5.01	4.08
Albumen coagulable by boiling	0.23	0.24	0.15	0.17
Albumen in cupric hydrate sediment	0.95	0.82	0.69	0.57
Albumoses	0.89	0.87	0.91	0.84
Peptones	0.85	0.76	0.54	0.44
Amides	4.01	3.16	3.41	2.63

These results showed that if the foam-holding capacity of beer really depends upon certain albuminoids, whether peptones proper or albumoses, or both, a lower initial mashing temperature yields, at least practically, the same amount of albumoses and considerably larger quantities of peptones for the wort than a high initial mashing temperature. The amount of amides, it will be seen, is also much greater, so that the low initial mashing temperature gives considerably more yeast food. Moreover, the figures show that there is no breaking down of the higher molecular albuminoids into those of lower molecular constitution in consequence of lower initial mashing temperature, as surmised by Windisch, otherwise the amount of albumoses in the wort made by Wahl's method ought to be considerably less than in the wort made by the Windisch method.

In June, 1897, *Wahl* published the results of investigations (*American Brewers'* Review, Vol. X, page 462) made in order

to determine which class of albuminoids possesses the highest degree of foam-producing power. For this purpose preparations were employed containing albumoses, peptones and amides in different quantities. The solutions were diluted and shaken so as to produce foam, and the height and consistency of this foam and time before it collapsed were noted. Following were the results:

1. The relative foam-producing power of a body can be ascertained by violently shaking a solution, properly diluted, of this body and observing the height, fineness and stability of the foam thus obtained as compared with other foam-producing bodies.

2. Among the substances examined, the albuminoids possess by far the greatest capacity for producing foam.

3. Among the albuminoids, the amides and peptones have a much greater share in the production of foam than the albumoses.

4. The coagulable albumen, or so-called protein, has no foam-producing capacity whatever.

5. The foam produced by beating the white of eggs is not caused by the coagulable albumen but the non-coagulable albuminoids.

6. Assuming that the substances contained in wort and beer and obtained from malt and other materials will act the same as the substances with which the above experiments were made, particularly the albuminoids, as proteins, albumoses, peptones, and amides, it should be the aim in the preparation of beer to secure large amounts of albumoses, peptones, and amides, whereas the proteins must be considered as detrimental, since they can be precipitated and impair the foam-producing properties of beer.

7. Among the albuminoids, the peptones are the most valuable, for the reason that, like the amides, they have an essential function in the production of foam, but unlike the amides, are not removed from beer by the yeast.

In August, 1897 (American Brewers' Review, 1897, Vol. X, page 44), R. Wahl and L. Henius added further evidence going to prove the correctness of Wahl's theory by showing that worts prepared by Wahl's method with low initial temperature, as compared to Windisch's method with high initial temperature, were of superior quality for the following reasons:

1. *The wort made with* a low initial mash temperature filtered *quickly from the grains* and was almost brilliant;

2. The wort made with a high initial temperature filtered slowly from the grains and was quite turbid;

3. The wort prepared with low initial temperature of mash, when shaken as above described, possessed greater foam-producing power, the bubbles of foam were much finer and the foam stood much longer than in worts made according to Windisch;

4. Being boiled, the Wahl wort broke or clarified excellently and almost immediately upon coming to a boil, whereas the Windisch wort broke imperfectly even after extended boiling. On cooling the worts after boiling and filtering hot, it was found that they always became turbid on being cooled to 40° F. (3.5° R.), but broke gradually. The worts were kept at 40° F. (3.5° R.), and it was found that after the expiration of seven days the Wahl worts were fairly clear, whereas the Windisch worts displayed a pronounced haze, proving that the latter worts contained a larger quantity of undesirable, more slowly settling, proteids, that is, such as give rise to beer turbidities, than the former.

Only a short time since, Windisch succeeded in proving the existence of a proteolytic enzyme, that is, peptase, in malt. This enzyme, he finds, exercises its action upon such vegetable albumen only as has been rendered soluble by the process of germination, thus corroborating the views expressed all along by the Scientific Station for Brewing of Chicago, which institution has based many of its recommendations for the carrying out of brewing operations on the results of the experiments obtained in their laboratory and described above.

Messrs. A. Fernbach and L. Hubert, on June 25, 1900, almost contemporaneously with the paper of Windisch and Schellhorn (Wochenschrift f. Brauerei, XVII, page 334, and American Brewers' Review, Vol. VII, page 91), presented a note to the Académie des Sciences, in which they stated, that they had proved the presence of a proteolytic enzyme in malt from the fact that the coagulable albuminoids become non-coagulable when the extract, rendered absolutely sterile by passing through a Chamberland filter, was submitted to auto-digestion between ordinary temperatures and 160° F. (57° R.). This enzyme is, according to the authors, capable of inverting albumen, which substantiates the general supposition in regard to this enzyme.

It was only quite recently that unmalted cereals were tested in *the laboratory of* Wahl & Henius, with a view of determining

whether their employment in brewing increases the amount of albuminoids in wort or beer, and the peptase of the malt is capable of dissolving albumen from unmalted cereals; incidentally also to determine the amount and quality of extract that various unmalted cereals will yield when mashed together with malt.

Samples of Minnesota, Wisconsin, Utah and Iowa barleys, and of wheat, rye, oats, Indian corn and rice were analyzed in order to determine the quantity of moisture, nitrogen (albumen), mineral matter and raw fiber they contained. (See "Brewing Materials.")

The results of these experiments may be summarized as follows:

1. Unmalted cereals, like rice, corn, wheat, barley and oats, when boiled and then mashed together with malt according to the usual laboratory method, will yield amounts of albumen which vary from one-quarter of 1 per cent of the weight of the raw cereal in the case of rice to about one-half per cent in the case of corn, and about 2½ per cent in the case of wheat to 3.12 per cent in the case of rye, although the amount of albumen contained in the different cereals does not show very great differences.

2. If the raw cereals are mashed without previous boiling and without malt, they yield practically the same amount of albumen as if they are mashed with malt, whether they are previously boiled or not.

3. Little of the albumen thus coming from the unmalted cereals is coagulable, that is, most of this albumen is to be classed as desirable albuminoids. In case of wheat, rye and oats, the worts remained hazy after boiling and cooling, whereas with rice and corn, there was no haze in such wort.

4. The albuminoids yielded by the raw cereals are mostly preformed in the cereals, and there seems to be only a small quantity formed during the mashing process. The peptase of malt is without action on the albumen of unmalted cereals, since barleys mashed without malt under the same conditions as with malt, yield the same amount of albumen in the wort.

5. Unmalted barley gives a lower yield when mashed with malt than an average malt by itself, although the barley contains a higher percentage of starch than malt. This deficiency in the yield *is due to the smaller* amount of albumen yielded by the barley *as against malt.*

BREWING MATERIALS.

In order to prepare a perfect beer, coming up to all requirements, uniting a pure taste with a brilliant appearance, palatefulness, a creamy, lasting head of foam, and sufficient stability, the prime requisite is to employ faultless materials. Good beer can be made only from good materials, and it is incumbent upon the brewer who is responsible for the quality of the beer, to be able to judge whether the goods supplied to him are suited to the purpose or not.

This chapter is devoted to a detailed discussion of the various brewing materials. Attention is called to the points to be inquired into in valuing a material, and the properties enumerated and explained which such material ought to possess in order to yield a good product. On the other hand, it is pointed out what properties in brewing materials detract from their value or make them quite unfit for brewing purposes.

After a discussion of the water, which plays a most important part in brewery operations, attention will be first given to such materials as supply the extract in the wort, and, at a later stage, the extract, alcohol and carbonic acid of the beer. Under this head we find chiefly those materials which yield starch, that is, cereals, which are used either after undergoing the process of malting, or unmalted, in the form of raw cereals, and, lastly, the various brewing sugars. To this must be added those materials from which the beer derives the hop aroma and the pleasing bitter taste, viz., either the whole hops or the preparations therefrom which are used in place of the entire hops, as lupulin and hop extract. A discussion of coloring materials, as color malt and the various fluid beer colors, concludes the description of brewing materials proper, which constitute what *may be called* brewing materials in the narrow sense of the *term.*

Brewing materials, in a broader sense of the term, which do not yield any substance to the wort or beer, but are indispensable aids in producing the beverage, and hence are not brewing materials, as the term is strictly construed, are next taken up. Under this head are counted varnish and pitch, clarifying mediums, as chips and finings, and the various chemicals which, on account of their germicidal action, are used for cleaning cellars and vessels, and preventing mouldy growths.

In conclusion, there are given some directions how to prepare and ship samples of the various materials or products of the brewery for chemical or microscopical examination to a laboratory devoted to such purposes. For the sake of ready reference these directions are not confined to brewing materials, but also refer to finished or intermediate products, as beer and wort, in fact, all substances that it may be desirable to have examined in the course of brewing operations.

WATER.

The water used in brewing operations may be classified under several points of view:

a. According to the amount of mineral substances contained in them.

1. Hard waters.
2. Soft waters.

b. According to the organic substances, products of putrefaction, or organisms they contain:

1. Pure waters.
2. Impure waters.

c. According to their origin:

1. Rain water.
2. Condensed or distilled water.
3. Lake water.
4. River water.
5. Spring water.
6. Shallow well water.
7. Deep well water.

In estimating the value of a water regard should be had to its availability for:

1. *Malting.*
2. *Brewing.*

3. Watering yeast.
4. Feeding boiler.
5. Washing vessels, implements and bottles.
6. Cooling.
7. Dissolving finings.
8. ~~Watering-horses.~~ Cleaning [illegible]

According to the purpose for which it is intended, water is judged by the amount contained in it, of:

1. Mineral constituents.
2. Organic substances.
3. Living organisms.

Water takes up various constituents on its passage through the soil. Some are soluble directly in water; others are made soluble by carbonic acid, which the water takes up while falling through the air in the shape of rain, or from the soil. The solvent action of carbonic acid is noted with reference to carbonate of lime and magnesia, which, being encountered in the soil in an insoluble form, are converted into soluble bicarbonates by the carbonic acid of the water.

The substances contained in water in general are:

1. "Gases:" Air (oxygen), carbonic acid, sometimes sulphuretted hydrogen (noticeable by its odor).

2. "Organic substances" and "microorganisms" and the "products of decomposition" set up by them, as ammonia, nitrous and nitric acid (all of which are undesirable in brewery operations).

3. "Mineral constituents."

- a. Lime in the form of bicarbonate of lime, sulphate of lime or gypsum, chloride of calcium.
- b. Magnesia, in the form of bicarbonate of magnesia, sulphate of magnesia or Epsom salts, chloride of magnesium.
- c. Sodium, in the form of chloride of sodium or common salt, sulphate of sodium or Glauber salt, bicarbonate of sodium.
- d. Potassium in the form of chloride, sulphate, or bicarbonate of potassium.
- e. Iron, in the form of bicarbonate of iron.
- f. Aluminum in the form of hydrated oxide of aluminum.
- g. Silicic acid.

HARDNESS OF WATER.

According to the amount of mineral constituents contained in solution, some waters are called hard and some soft. In the case of hard water, a distinction is made, according to the nature of the minerals it contains in solution, between temporary and permanent hardness.

Temporary hardness is shown by those waters which, upon boiling, throw up a white film, form a white sediment and become softer. This is caused by bicarbonates of lime, magnesia, alumina, or iron giving off part of their carbonic acid in boiling, whereby they become insoluble and are precipitated. Long exposure to air while standing will also soften such waters.

Analysis of a water of temporary hardness:

	Sodium chloride.	Sulphate of lime.	Carbonate of lime.	Carbonate of magnesia.	Total residue.— Before boiling.	After boiling.
Grains per gallon	2.1	4.2	14.4	9.9	30.6	6.3
	remains in solution.		is precipitated in boiling.			

Permanent hardness is shown by waters which do not become softer by boiling. Causes: Sulphate of lime and magnesia, chloride of calcium and of magnesium.

The hardness of any given water is subject to great fluctuations.

Analysis of a permanently hard water:

	Sodium chloride.	Sulphate of lime.	Carbonate of lime.	Carbonate of magnesia.	Total residue.— Before boiling.	After boiling
Grains per gallon	5.6	27.4	1.5	1.1	35.6	33.0
	remains in solution.		precipitated by boiling.			

"Order of Waters according to Hardness." The deeper below surface a water is taken, the harder it is, as a rule, since the opportunities for taking up mineral matters are the greater, the deeper it has sunk into the earth. On the other hand, water will become softer in proportion as it is exposed to the air. Hence the following order of waters, according to hardness:

Artesian water.
Spring and well water.
River and stream water.
Lake water.
Rain water.
Condensed or distilled water.

"The Order of Waters, according to Purity," is about as follows:

Condensed or distilled water.

Spring water.
Artesian water.
Well water.
Lake water.
River water.
Rain water as usually collected.

The amount of organic matter is the less, the deeper the water is taken from the ground, and, on the other hand, the greater, the longer it remains in contact with putrefying substances on the surface of the soil.

"Degrees of Hardness." For the purpose of comparing the hardness of different waters certain standards are in use, which are as follows:

1 German degree of hardness: 1 part lime, calculated on calcium oxide, in 100,000 parts water.

1 French degree of hardness: 1 part carbonate of lime in 100,000 parts water.

1 British degree of hardness: 1 grain carbonate of lime in 1 British gallon of water.

The amounts of the various constituents of a water are stated in parts per 100,000, or per million parts of water. In the United States they are mostly stated in grains per United States gallon.

ACTION OF CONSTITUENTS HELD IN SOLUTION.

If the substances enumerated occur in the water in considerable quantities, their action is felt in the following manner:

1. Organic matters and microorganisms promote putrefaction and mold.

2. Ammonia, while harmless in itself, indicates the presence of putrefying matter and bacteria of putrefaction.

3. Nitrous acid hinders saccharification, is a strong yeast poison, may cause disturbances in fermentation, and, being a product of ammonia oxidation, indicates the presence of products of putrefaction. In fermentations at high temperatures (top-fermentation) the beer may acquire an offensive odor, as of chlorine (Windisch).

4. Nitric acid is injurious only if present in quantities by impeding steeping and the beginning of germination, hindering the development of the radicle. In the presence of de-nitrifying (reducing) bacteria, nitric acid may be transformed into nitrous acid, which will then exercise its pernicious influence.

5. Chlorine. Large amounts of chlorine, particularly if coupled with a simultaneous large amount of ammonia, makes a water suspicious, as it suggests the possibility of infection by drainage, particularly sewage, animal or human excrements and bacteria. The chlorine compounds have the following action:

Sodium chloride delays steeping of the barley and the beginning of germination, impedes the development of the rootlets, and promotes the growth of the acrospire.

Magnesium, or calcium chloride, has a similar action in malting, and is particularly detrimental in boiler feed water since it has a powerful corrosive action on the boiler shell.

6. Lime.

a. Sulphate of lime is desirable for malting and brewing, particularly for producing pale beers. It extracts from the barley less of the valuable constituents, precipitates albuminoids in boiling more completely and in more coarsely flocculent form, while extracting less of the coarse and rank matters from hops. It is undesirable for boiler feeding, as it forms very hard scale.

b. Carbonate of lime. On the whole, rather unimportant, undesirable for boiler feeding, if in large quantities, as it forms scale; desirable constituent for the production of extra pale beers.

c. Calcium chloride. See under Chlorine.

7. Magnesia. A moderate amount is desirable. Larger quantities often cause diarrhœa, magnesia having a strong laxative action. For magnesium chloride, see under Chlorine.

8. Sodium. According to researches in the laboratory of Wahl & Henius, bicarbonate of soda, making a water alkaline, is undesirable, even in small quantities. In malting it hinders the growth of the acrospire, in brewing it weakens the diastase, and thereby delays saccharification of the mash. Gives dark colored beers, stubborn of clarification. Neutralizes the lactic acid of the wort, and hence the beer is more exposed to the action of microorganisms, increasing the liability to bacterial turbidity. In boiler feed water it is apt to cause foaming.

For sodium chloride see under Chlorine.

9. Iron, in larger quantities, produces an off-colored, gray malt, darkens the wort in mashing by uniting with the hop tannin to tannate of iron (ink), which imparts to the beer an inky taste. Colors yeast dark.

PROPERTIES OF BREWING WATER.

The fitness of a water is judged by the purpose for which it is to be used. Thus:

1. For malting: Pure, moderately hard water, with gypsum, poor in nitrates, iron and chlorine compounds, practically free from decaying organic matter, microorganisms (molds, bacteria of putrefaction), ammonia. Excessively soft water extracts too much mineral matter from the barley, which is required for yeast food. The temperature of the water should be uniform, for cold water delays the steeping process, warm water accelerates it, but also promotes noxious mold growth. Fluctuating temperatures produce irregular steeping.

2. For Brewing. Moderately hard water, with a certain amount of sulphate of lime and common salt, poor in soda and iron; for very pale beers, poor in carbonates. The purity of the water is of less moment in this respect, as long as the water remains without odor or taste, since microorganisms are rendered innocuous by boiling the wort.

3. For Washing Tanks, Bottles, Barrels, etc. Water should be without any considerable amount of decaying matter.

4. For Watering Yeast. Moderately hard, pure water from springs or shallow wells. Condensed water is best, after hardening, by adding plaster of Paris.

5. For Dissolving Finings. Soft water of good purity.

6. For Steam Boiler. The softest water that can be had, particularly free from sulphate of lime, sodium carbonate, chlorides of calcium and magnesium and organic matter.

7. For Cooling. Water should be free from acids and without too great temporary hardness, since the precipitated carbonates would, in the course of time, stop up the pipes.

8. For Watering Horses. Moderately hard, pure water.

IMPROVING WATER.

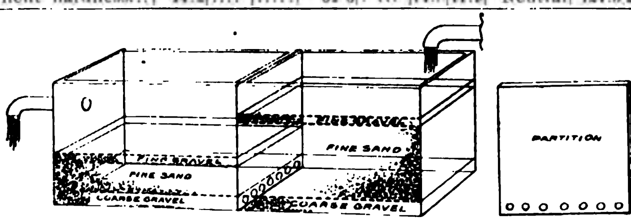
If a water does not come up to all requirements, it may in many cases be improved by a variety of means.

Purifying from suspended matter and bacteria. Impure water with an excess of substances in suspension or of micro-organisms is purified by filtration through sand or other filtering devices, and the number of bacteria materially diminished. The construction of a sand filter, easy of preparation, may be seen from the accompanying sketch.

TABLE OF TYPICAL AMERICAN WATERS (LABORATORY OF WAHL & HENIUS, CHICAGO).

Mineral constituents are given in grains per gallon.

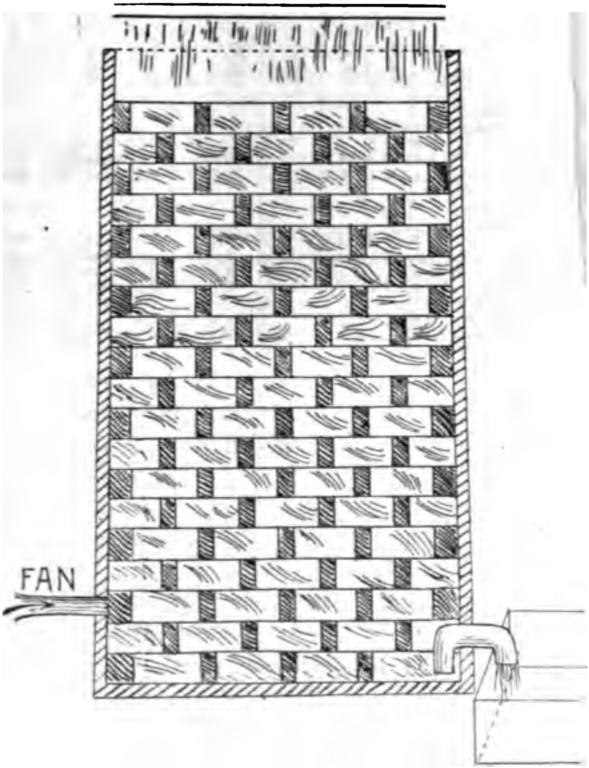
	NaCl.	Na_2SO_4.	Na_2CO_3.	$CaSO_4$.	$CaCO_3$.	$MgSO_4$.	$MgCO_3$.	Reaction.	Total Residue.	Loss in Red Heat.
Water with large amount of common salt....	46.8	11.5	....	21.3	....	....	7.4	Neutral	97.9	8.2
Alkaline water. ..	2.4	0.5	28.5	....	Trace	....		Alkaline	33 8	2.4
Alkaline water.....	2.4	3.1	5.0	....	4.2	....	4.2	Alkaline	23 2	4.4
Alkaline water with large amount of Glauber salt...........	8.2	57.4	14.0	.....	3.7	....	1.5	Alkaline	80.4	3 8
Very soft water ..	....	.....	.....	....	1 5	....	....	Neutral	2.1	0.6
Very soft water....	Trace	.....	.....	Trace	2.4	....	0 5	Neutral	5.3	2.4
Medium soft water	0.7	1.6	.....	....	5.0	....	2.3	Neutral	11.2	1.6
Medium soft water	0.7	.....	. .	0.5	2.6	....	1.0	Neutral	6.2	1.5
Medium soft water	0.6	.....	....	2.4	4.5	....	2.5	Neutral	10 6	0.6
Medium hard water	Trace	.....	.....	5.2	8.4	....	6.5	Neutral	23.5	3.5
Medium hard water	Trace	.....	.....	1.7	7.3	....	6.4	Neutral	20.0	5.3
Water of temporary hardness. ..	2.1	.....	.....	4.2	14 5	....	10.0	Neutral	29.4	8.0
Water of temporary hardness....	6.9	.....	.....	3.9	13.1	....	11.7	Neutral	42.9	7.1
Water of permanent hardness. .	5.0	.....	....	24 9	12.3	....	12.2	Neutral	61.7	13.2
Water of permanent hardness.	0.7	.....	.....	37.3	4.1	....	20 0	Neutral	68.5	6.8
Water of permanent hardness.	14.7	....	.....	22.0	18.3	....	8.6	Neutral	75.3	11.5
Water of permanent hardness...	14.2	....	.....	62 6	. ...	14.8	11.9	Neutral	121.5	27.1



Sand Filter.

An excess of organic matters, ill-smelling gases and iron may be diminished or removed by artificial aeration, the air blown through oxidizing the organic matters, carrying off the gases, and transforming the iron into insoluble iron oxide, which settles on the bottom. The water may be aerated by running the water over the surface cooler, over bundles of twigs (Gradir-

werk), by a sprinkling rose, or forcing-in air. A suitable aerating device may be constructed with the aid of an old storage tank according to the accompanying sketch. Water may also be improved by boiling.



Aerator.

Hardening waters that are too soft (Burtonizing). An addition of plaster of Paris, sulphate of magnesia, or common salt, preferably in a powder in the hot water tank, will make soft water more suitable, particularly for very pale beers. The amounts of these salts to be applied are governed by the properties of the water in question.

Making Injurious Constituents Indifferent. If a water contains an excess of alkaline carbonates (soda), it is improved by an addition of a suitable amount of calcium chloride. This salt will neutralize the alkaline carbonates, but the quantities to be added must be accurately calculated.

The chlorides of magnesium and calcium are modified into the harmless carbonates of magnesium and calcium by an addition of carbonate of sodium. Sulphate of sodium is changed into sulphate of lime and common salt by an addition of calcium chloride.

Softening hard water, particularly for boiler feeding:

1. By boiling. This is useful for temporary hardness only. If a water of temporary hardness is boiled for half an hour and allowed to settle or filtered before using, the bicarbonate of calcium and magnesia will be eliminated and the water softened.

2. By chemicals. Feed-water may be softened either before or after it enters the boiler, the latter course being preferable. It is best done (see Boiler Compounds) by adding:

	Precipitates:
Soda lye (caustic soda).	Bicarbonate of lime and magnesia.
Sodium carbonate (crystallized or washing soda).	Sulphate of lime.
Trisodium phosphate.	Sulphate of lime and bicarbonate of lime and magnesia.
Sodium fluoride.	Sulphate of lime and bicarbonate of lime and magnesia.
Milk of lime (only outside of the boiler).	Bicarbonate of lime and magnesia.

It is indispensable to have the water analyzed before treatment. Where the above remedies are used, the minerals that cause the temporary or permanent hardness are eliminated not in the form of a solid crust, but in a powder-like, muddy condition, and can be ejected by blowing off, if the boiler compound was added in the boiler, after the boiler has cooled down, otherwise the precipitated powder will harden into solid pieces.

In using caustic soda, sodium carbonate, trisodium phosphate, and sodium fluoride in the boiler, the requisite amount, which has been previously accurately calculated, is either pumped into the boiler in the form of a concentrated solution, or, in the case *of the first two articles,* the requisite amount need not be calcu-

lated in advance, but the concentrated solution is kept running into the boiler until a sample of the water will color red litmus paper slightly blue. From time to time this test is repeated and more concentrated solution added if necessary.

The four above articles may also be used outside of the boiler; also milk of lime, which is efficient only for temporary hardness. In using milk of lime for temporary hardness, first note the parts per million of carbonate of lime contained in the water, multiply the figures by 0.014 and the product will give the number of pounds of burnt lime to be taken per 100 barrels of water, slake the lime in a little water, stir it to a thin milk of lime, and add to the water, which should be in a tank provided with exhaust steam. Stir well, heat to a boil, and boil for 15 minutes, let settle, and after two hours draw off the clear water.

Sodium carbonate, often called soda, is used sometimes together with substances containing tannic acid, as extracts from the bark of trees. If inferior material is employed in making this compound a peculiar odor may be imparted to the steam, precluding its use in the mash-tub or cooker, in fact, wherever live steam is used.

ENGLISH BREWING WATERS.

Sykes treats at length on the requirements of brewing waters in England. The following quotation is from his book, "Principles and Practice of Brewing," 1897, pp. 375 to 377.

Waters Adapted for Producing Pale Ales.—The waters most suitable for the production of pale ales are those which contain calcium sulphate in fairly large quantity. Of these the Burton waters may be taken as typical examples. The following are the results of an analysis of the water from a deep well situated in that town: (All analyses of English waters are given in English weights and measures.)

	Grains per gallon.		Grains per gallon.
Silica	0.49	Sodium chloride	3.90
Alumina	0.49	Potassium sulphate	1.59
Iron oxide	trace	Sodium nitrate	1.97
Lime	36.33	Sodium sulphate	10.21
Magnesia	10.15	Calcium sulphate	77.87
Soda	7.25	Calcium carbonate	7.62
Potash	0.86	Magnesium carbonate	21.31
Chlorine	2.37	Silica and alumina	0.98
Sulphuric acid	52.29		
Nitric acid	1.25		

In this and similar waters the amount of calcium sulphate is exceedingly high, whilst a fair amount of calcium and magnesium carbonates, which are precipitated on boiling, are also present; the chlorides are very small in quantity. The amount of calcium sulphate in this particular water is undoubtedly very large, and most probably all the possible beneficial effect to be derived from the presence of calcium sulphate in a brewing water may be obtained with from 40 to 50 grains per gallon of that salt.

Waters Suitable for Black Beers.—As a contrast to this class of waters, an analysis of one of the Dublin well waters is appended:

	Grains per gallon.		Grains per gallon.
Silica	0.26	Sodium chloride	1.83
Iron oxide and alumina	0.24	Calcium sulphate	4.45
Lime	9.79	Calcium carbonate	14.21
Magnesia	0.43	Magnesium carbonate	0.90
Soda	0.97	Iron oxide and alumina	0.24
Chlorine	1.11	Silica	0.26
Sulphuric acid	2.62		

Waters of this class are distinguished by the small quantity of calcium sulphate and all the other constituents, with the exception of calcium carbonate, which they contain. This last salt is almost entirely removed on boiling such a water.

Waters Fitted for Mild Ales.—The following is the analysis of a water adapted for the production of mild ales:

	Grains per gallon.		Grains per gallon.
Silica	0.22	Sodium chloride	35.14
Iron oxide and alumina	0.24	Calcium chloride	3.88
Lime	13.13	Calcium sulphate	6.23
Magnesia	1.91	Calcium carbonate	16.37
Soda	18.62	Magnesium carbonate	4.01
Chlorine	23.81	Iron oxide and alumina	0.24
Sulphuric acid	3.67	Silica	0.22

The essential characteristic of this class of waters is the high amount of chlorides and the comparatively small amount of calcium sulphate which they contain.

ARTIFICIAL TREATMENT OF BREWING WATERS.

From the above generalizations of the inorganic constitution of those waters which have been found by experience to be the best fitted for the production of the different classes of ales, it is

obvious that no single water possesses the qualifications necessary for producing every class of beer. Fortunately, the knowledge acquired during the past few years has shown that it is possible so to modify the inorganic constitution of many waters that this important result may be attained. Some waters do not lend themselves so readily to this treatment, and there still remain others which it is absolutely impossible to convert into good brewing waters. As an example of the first of these may be adduced the waters from the chalk, which are very frequently met with, and which are highly valued for brewing purposes.

The following is the analysis of one of these:

	Grains per gallon.		Grains per gallon.
Calcium carbonate.......	17.92	Calcium chloride........	0.21
Magnesium carbonate....	0.49	Sodium chloride.........	0.84
Calcium sulphate........	0.07	Magnesium nitrate......	1.05
Potassium sulphate......	0.56	Silica	1.12

Such a water as this, without any other treatment than boiling, is eminently fitted for the production of black beers, since, when boiled, the carbonates are almost completely precipitated, and very little solid matter of any kind remains in solution.

To convert such a water into one suitable for the production of pale ales, an addition of those salts in which the water is deficient must be made, and its inorganic constitution brought more into agreement with that of a water of Type I., of which an analysis has just been given.

Thatcher says that the majority of methods suggested from time to time for the artificial treatment of brewing waters or liquors have proved more or less unsatisfactory. He recommends to make a solution of all the salts, and then add in the liquor tank prior to heating for mashing. He gives the table printed on the next page for the treatment of waters (Brewing and Malting Practically Considered, 1898, pp. 10 to 11).

(If any brewing waters possess saline or alkaline substances different to those given in the table, they should, where possible, be so altered in character as to bring them to this standard. If present in excess of the figures in the table, the addition of more will be unnecessary, but when a water is deficient in these inorganic *substances, they should* be added as directed.)

TABLE FOR THE TREATMENT OF SOFT WATER FOR VARIOUS BEERS.

Saline or Alkaline Salts to be Added For	Pale Running Ales.	Stock Ales.	Mild Ales. "or"	Mild Ales	Stout and Porter. "or"	Stout and Porter.	Add Extra for Moisture Present in Salts Used.
Calcium sulphate........ ($CaSO_4$)	30	40	20	20	—	—	25%
Magnesium sulphate..... ($MgSO_4$)	10	15	—	—	—	—	50%
Calcium chloride.......... ($CaCl_2$)	10	5	—	—	—	—	50%
Sodium chloride......... ($NaCl$)	10	5	—	30	35	—	25%
Kainit..................... $K_2SO_4+MgSO_4+MgCl_2+6H_2O$	—	—	30	—	—	35	25%
Sodium carbonate........ Na_2CO_3	—	—	—	—	10	—	25%
Total grains per gallon.	60	65	50	50	45	35	—

GERMAN BREWING WATERS.

Thausing gives a number of analyses of brewing waters used in Germany and Austria, which are condensed in the following table:

Grains per Gallon.	Bürgerliches Bräuhaus Pilsen.	Pilsen Genossenschafsbrauerei.	Klein Schwechat, near Vienna.	Vienna Brewing Water.	Munich City Water.	Spatenbräu, Munich.	Löwenbräu, Munich. I.	Löwenbräu, Munich. II.	Hofbrauhaus, Munich. I.	Hofbrauhaus, Munich. II.
Total residue.....	3.01	9.12	22.35	30.00	16.59	31.77	31.30	16.76	35.29	28.53
Loss by ignition.	0.35	......	4.94	......	......	11.47	10.06	3.72	12.65	7.94
Ferric oxide.....	trace	trace	0.01	0.04	......	trace	......	......	trace	trace
Lime.............	0.58	2.12	5.08	8.82	6.54	13.53	11.18	10.35	9.61	13.33
Magnesia.........	0.25	0.78	2.52	3.55	2.06	6.63	4.14	2.43	5.19	4.52
Potash	......	......	0.88	......	0.12	......	......	......	......	......
Soda	0.15	0.19	0.77	1.3	0.14	......	......	......	......	......
Sulphuric acid...	0.25	0.81	4.03	5.41	0.42	trace	little	1.07	3.27	little
Silicic acid.......	trace	......	0.56	0.80	0.38	......	......	......	......	......
Chlorine	0.18	0.48	0.86	2.35	0.28	much	trace	trace	2.44	little
Phosphoric acid.	......	......	0.005	......	......	......	......	......	......	......
Nitric acid.......	trace	1.05	......	......	......	......	......	......	......	much
Ammonia	......	......	......	......	......	......	......	......	......	......
Organic matter..	*0.8*	*0.49*	0.33	......	......	1.16	0.71	0.71	0.88	1.06
Hardness in German degrees...	*1.57*	*5.5*	14.63	23.4	16.02	38.77	29.0	23.4	29.03	33.[illegible]

EXTRACT-YIELDING BREWING MATERIALS.

From the materials which yield the extract, the wort receives, in a general way, the following constituents:

1. Sugar.
2. Dextrin.
3. Albuminoids.
4. Mineral substances.
5. Lactic acid.

The starch-containing materials give all of these substances, the sugars only sugar or dextrin. Sugar and dextrin are products of starch inversion. The albuminoids are modifications of the insoluble albuminoids of various materials.

All the constituents extracted from the materials by water, largely with the aid of enzymes, are comprehended under the term "extract." On the whole, a material is the more valuable the more extract it will supply. If it is desired to use other materials besides malt, their value is estimated by

1. The amount of extract they will yield in the mash.
2. The composition of such extract.

As a general proposition, the malt adjuncts contain insignificant amounts of desirable albuminoids, lactic acid and mineral substances, consisting very largely of starch (except the sugars).

STARCH-CONTAINING BREWING MATERIALS.

The starch-containing materials are the principal ones, in point of quantity, that are used in brewing. Some are used in a malted condition as barley and wheat malt, others are used unmalted and are called raw cereals, among which the main ones are corn, rice, prepared corn, also rolled wheat. Although other materials may be used, they must remain adjuncts, the greater amount of barley malt being indispensable.

The value of starch material is governed by

1. The amount of starch.
2. The readiness with which this starch can be opened up or made available.
3. The composition of the extract obtained.

BARLEY.

History.—The history of barley culture in the western states of the Union may be dated from the settlement of German pioneers in the territory which is now the state of Ohio. It is not known from what seed the Ohio fall barley, which, until 1888, was the only kind used for malting in Ohio, was derived. The time when brewing barley from the western states began to be a factor in the markets of the Union may be fixed about 1875-1880. In the eastern states only local or Canadian barley was used up to that time, although at present they are the principal markets for western barley and malt. It was difficult to convince the brewers that the continual improvement of western barley owing to its closer relation to the soil was really worthy of consideration. Wisconsin and Iowa at that time were growing a barley which was called Scotch and adapted itself most completely to the soil. Minnesota and Nebraska were raising a Canadian variety. All of them stuck to the original seed, with few variations. The climate proving unfavorable there, Nebraska has ceased to occupy an important place among the barley growing states.

QUALITIES OF BARLEYS OF DIFFERENT STATES.

Some western states, principally the Dakotas, grow a barley which is steadily improving. It was derived from the European Saale barley. The Pacific Coast and Montana raise a fine barley, called Chevalier and Bay Brewing, which is derived from Saale, Hanna and Moravian barley. This product is, for the most part, marketed on the Pacific Coast and in Europe. Numerous tests have shown that the barleys of the middle West are best suited for the preparation of American malt and American beer.

The soil of the states of Wisconsin, Minnesota and Iowa is peculiarly fitted for growing barley, being largely made up of calcareous clay and rather sandy. Often, however, the barley suffers from sudden changes in temperature. The chinch bug has been gradually forcing the barley fields further north, and extensive regions in Southern Wisconsin have given up barley growing altogether on account of the bug.

Taking an average, Iowa barley comes first in color, form, and mealiness of the berries. Wisconsin gives a bigger berry of medium and often pale color with an inclination toward glassiness. *Minnesota barley* is smaller. Dakota barley is getting bett

from year to year, but will have to undergo a more extensive test before its character can be considered settled. Wisconsin and Minnesota have a soil peculiarly suited for barley growing, whereas the climate is better in the latter state and Iowa. Ohio and Indiana play no great part as barley growers. Northern Illinois may be taken into consideration, but is losing ground fast in favor of more northerly regions on account of the chinch bug.

Influence of Fertilizers on the Quality of Barley.—In raising barley farmers are apt to make a mistake in using fresh manure and too much of it. This promotes the growth of straw and thick husks, and augments the quantity of albuminoids at the expense of the starch. Proper manuring, uniform seeding, deep plowing and good aeration of the soil are highly important requirements to grow good brewing barley. In order to avoid vitreous corns the grain ought not to be cut before it is quite ripe, as is quite generally done.

VARIATION OF BARLEY OWING TO THE CLIMATE.

American barley differs from European in that it has no such firmly established character as to permit of adopting any rule that could be applied with any degree of certainty to its treatment. The reascn is to be looked for in the frequent sudden changes of weather and temperature.

STORAGE OF BARLEY.

Barley should be put in storage perfectly dry and well cleaned. It requires careful watching, especially in the summer time, to avoid heating. After remaining in storage through the summer until fall it is very desirable for malting until the new crop has fully matured. But there will be a loss of five to ten per cent of the germinating capacity at the end of the first year.

SUPERIORITY OF SIX-ROW BARLEY OVER TWO-ROW VARIETIES FOR AMERICAN BEER.

We distinguish, in the main, two different varieties of barley, viz., the two-row or Chevalier barley, used mainly in Germany and Austria, and the six-row barley, employed almost exclusively *for malting* in the United States.

Aside from the readily apparent differences in size of berry and amount of starch and husk, the two-row barley being larger, containing in proportion more starch and less husk, there

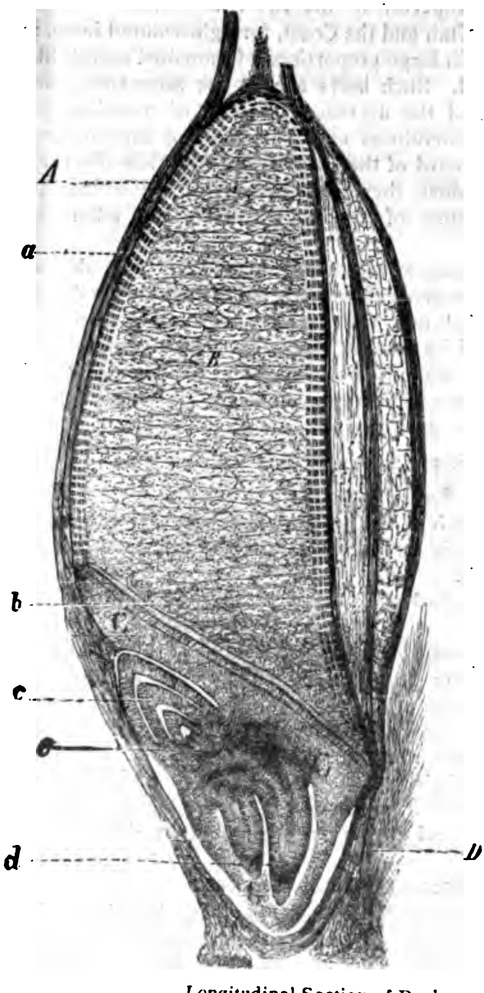
Long Short Bare
Two-row Barley.
(From Lehrbuch d. Bierbrauerei.—Carl Lintner.)

is, from the standpoint of American brewing, a decided advantage to be gained by employing the six-row barley. According to researches made in the laboratory of Wahl & Henius' Scientific Station for Brewing, the malts from such six-row *barley are richer in* diastatic and peptonizing power, so that i

mashing there is not only no difficulty encountered in the inversion of the starch contained in the malt, but large amounts of starch from unmalted cereals can be taken care of very readily,

Short Long
Six-row Barley.
(From Lehrbuch d. Bierbrauerei.—Carl Lintner.

while the resulting worts are, at the same time, richer in desirable albuminoids—amides, peptones, and albumoses—and the proteids formed, on the other hand, are much more readily precipitated by boiling or by subsequent cooling than in worts produced from malts from two-row barleys.



A. Husk.
B. Endosperm (starch body).
C. Germ (embryo).
D. Basal bristle.

a. Aleurone layer.
b. Scutellum.
c. Plumula (acrospire).
d. Radicles.
e. Axis of germ.

Longitudinal Section of Barleycorn.
(*From Malzbereitung und Bierfabrikation.*—J. E. Thausing.)

Hence, the six-row barley as it is grown in Wisconsin, Minnesota and Iowa is superior to the two-row barley as grown in Dakota, Montana, Utah and the Coast, for light-colored beers, in the production of which large proportions of unmalted cereals like corn or rice are used. Such beers are, at the same time, more durable on account of the decreased amount of proteids they contain while the palatefulness and foam-holding capacity may be fully up to the standard of the German beers, unless too much raw cereal is used, since these two properties are mainly dependent on the amounts of amides, peptones, and albumoses yielded by the malt.

These great advantages are supplemented by the decided facility with which the processes of steeping, growing, and kiln-drying can be carried out, the barley absorbing water more readily on account of its smaller diameter, growing quicker on account of the larger amount of diastase and peptase developed, and admitting of proper kiln-drying more readily on account of the easier escape of the moisture out of the smaller kernel.

ANATOMICAL STRUCTURE OF THE BARLEYCORN.

Along one side of the barleycorn there runs a depression or furrow the whole length of the berry. A section of a corn made lengthwise through this furrow will show the interior as in the accompanying sketch.

The following principal parts are distinguished in the barleycorn:

1. Husk, consisting of spelt (epidermis) or exterior husk, and testa, the latter being subdivided into the pericarp and the seed integument.
2. The mealy part, called the endosperm.
3. The rudimentary germ, called the embryo.
4. The basal bristle, which serves to catch moisture from the air and conduct it to the berry.

The husk and the endosperm are separated by the aleurone layer.

CONSTITUENTS OF BARLEYCORN.

The husk, which serves the purpose of protecting the barleycorn, consists in the main of cellulose and contains some pigment.

The endosperm constitutes the greater part of the berry and *contains the starch* granules, which in turn are made up of starch

granulose, or starch proper, and starch cellulose, forming the outer cover of the starch granule.

The germ, located at the lower end of the berry, is a rudimentary plant, pre-formed in all parts, including leaves, stem and roots. The germ contains most of the fat present in the grain.

The aleurone layer is rich in albuminous bodies, which, however, are also found scattered throughout the berry.

Besides, the berry contains mineral matters, as silicic acid and phosphates, particularly those of lime, magnesia and potassium; also small amounts of sulphates and a little iron.

COMPOSITION OF VARIOUS AMERICAN BARLEYS AND OTHER GRAINS ACCORDING TO WAHL AND HENIUS.

Barleys.	Moisture.	Nitrogen.	x 6.25= Albumen.	Mineral Matter.	Raw Fiber.
Minnesota choice	11.65	1.41	8.83	2.68	5.40
Minnesota uncleaned, average common	12.05	1.47	9.18	3.18	6.93
Minnesota good eastern	12.30	1.44	9.00	2.93	5.35
Minnesota choice western	11.35	2.03	12.68	2.60	5.43
Wisconsin choice	12.83	1.73	10.84	2.57	4.38
Wisconsin eastern and central	11.55	1.64	10.28	2.70	4.95
Wisconsin western	11.15	1.59	9.93	2.53	5.28
Utah 2-row	11.90	1.42	8.92	2.67	3.33
Canada	11.05	1.48	9.25	2.77	4.90
Iowa choice	12.50	1.72	10.75	2.68	4.79
Iowa choice	10.95	1.57	9.81	2.50	5.13
Wheat	12.05	2.12	13.25	1.97	2.70
Rye	11.95	1.72	10.76	2.05	2.87
Oats	11.30	1.58	9.87	3.12	11.55
Corn	14.30	1.59	9.93	0.83	1.60
Rice	12.15	1.30	8.13	0.27	0.40
Malt	9.40	1.78	11.12	2.47	4.40

The constituents of barley besides moisture may be grouped according to their chemical classification, as follows:

1. Carbohydrates, the most important of which are:
   a. Starch, which forms the mass of the endosperm and makes up 60 to 80 per cent of the weight of the berry.
   b. Cellulose, to the amount of 2.5 to 8.5 per cent, which makes up the chief ingredient of the husk and is also found in the endosperm enveloping the starch granules.
   c. *Sugars in* small quantities, mainly saccharose, raffinose or *melitriose*, which is almost identical with t[he] *former*.

d. Gummy substances, called amylanes, found by O'Sullivan, seem to differ from the galactoxylan of Lintner and Düll (Zeitschrift f. angewandte Chemie., 1891, p. 538), the xylan of Stone and Tollens (Annales de Chemie., 249, p. 227), and the laevosin of Tanret (Zeitschrift f. d. ges. Brauwesen, 1891, p. 77).

Besides these there are the pectin bodies of Ullik (Zeitschrift f. d. ges. Brauwesen, 1886, p. 303), which the latter found in beer and grains, and to the presence of which in beer palatefulness is ascribed by some.

2. Nitrogenous bodies. Amount 8 to 14 per cent, average about 11 per cent, of which about four-fifths is insoluble in water, composed of gluten-caseine and gluten-fibrine. The one-fifth soluble in water is composed of: Mucedin, little soluble in cold water, not coagulable by boiling; albumen or protein, readily soluble in cold water, coagulating when solution is heated; albumose; peptones; amides, readily soluble, not coagulable; and minute quantities of amido-acids, ammonia and nitric acid. An enzyme glycase, also a nitrogenous substance, was found by Kjeldahl in barley. (See Chemistry.)

3. Fat is contained in the barley to the amount of about 2.5 per cent.

4. Acids. Prior made an elaborate inquiry as to the amount and nature of the acids contained in barley and malt in all its stages. He found that the acidity of barley is due in the main to the presence of primary phosphates and less to the presence of volatile and fixed organic acids. For neutralization of the acids in 100 grams of dry barley he used the following amounts of decinormal alkali solution:

	Bavarian barley.	Bohemian.
Volatile organic acids	7.52	6.07
Fixed organic acids	6.65	5.50
Primary phosphates	32.67	27.45

This result, says Prior (Chemie. u. Physiologie d. Malzes, 1896, p. 41), is of importance in malting and brewing inasmuch as the primary phosphates combine with certain albuminoids of the malt, and the amount of primary phosphates presumably bears a relation to the amount of the soluble nitrogenous substances of the barley. (See also "Malting Operations.")

5. Mineral Substances. The amount of ash in barley varies from about 2.25 to 3 per cent, of which about one-fifth is potash, one-third phosphoric acid, one-quarter silicic acid, and one-tenth magnesia, besides small quantities of oxide of calcium, oxide of sodium, chlorine and sulphuric acid.

VALUING BARLEY BY EXTERNAL MARKS.

With respect to its value for brewing purposes, barley is chosen by external marks, or with the aid of simple devices and methods of examination. In the choice of barley the following characteristics require attention:

1. Form and Size of Berry. The berries should be of uniform size, plump and short. A hollow end where the germ is situated indicates that the grain has been damaged; a hollow, shriveled tip at the opposite end betrays exposure to frost or harvesting before maturity. Small grains contain less starch and more albuminoids, cellulose and ash. Barley of irregular size will germinate and grow irregularly.

2. Condition of Husk. The husks (spelts) should be thin and delicate, and make up as little as possible of the total weight of the grain, or thick as in six-row barleys, which offers advantages for American methods. It should be smooth or have fine cross wrinkles.

3. Hundred-Corn Weight. The weight of a hundred corns is 0.1 to 0.15 oz., or 3 to 4.5 g., averaging 0.106 oz. (Scientific Station of Chicago). Barleys weighing less than 0.1 oz. are as a rule not fit for brewing.

4. Color and Luster. The corns should be of uniform color and have a certain luster. For pale beers, barley must be of a pale or light straw-yellow. A greenish tint indicates unripeness. Darker, reddish or lead color coupled with red, brown or black tips forecasts irregular steeping and growth, mold and deficient germinating capacity. A gray tint may also be caused by a transparent speckled barley. If the color is brown and the germ clearly visible through the husk, it is certain the barley has been exposed to rain and become heated in the stack, which seriously impairs the germinating capacity. With increasing age, the color deepens and the luster fades.

5. Odor. It should be simply a straw odor. If upon breathing on a handful of barley a musty, heavy odor arises, there is reason to fear mold and impaired capacity of germination. If a bottle

is filled half full of barley and allowed to stand for half an hour, the odor will appear more clearly upon opening the bottle, if the barley is not sound.

6. Condition of Endosperm. If a grain of barley is cut in two it will show a white to gray mealy fracture in many shades. If the grains are largely mealy, the barley contains more starch and will give a more mellow or friable malt. Speckled or glassy corns have less starch and more proteids. Glassy barley will give an equal yield of extract with proper steeping, but requires more time in the steep, slower malting, grows irregularly and gives worts with high nitrogen content.

7. Purity. Barley should be as free as possible from dust, corns damaged by mechanical means or by vermin, grains of oats or seeds of weeds. Barley ought not to be mixed, that is,

EXAMINATIONS OF BARLEY (LABORATORY OF WAHL & HENIUS, CHICAGO).

	Maximum.	Minimum.	Average of 36 Analyses.
Weight of 100 corns	4.23 g	2.60 g	3.17g
Ungerminated corns	70 %	0 %	7.33%
Mealy	30 %	2 %	16.6 %
Half-glassy	78 %	22 %	51.8 %
Glassy	70 %	4 %	32 %
Bushel weight	52.5 lb.	45.5 lb.	48.6 lb.
Water	14.20%	10.25%	12.59%
Extract	64.98%	54.68%	59.41%
Extract in dry matter	72.41%	62.12%	67.98%

grains of different seasons or origin, or from different elevators should be kept strictly separate.

8. "Germinating Capacity" and "Germinating Energy." The germinating capacity is indicated by the number of grains that germinate at all. In a good barley the germinating capacity is not less than 95 per cent. Germinating energy means the power of barley to germinate within two days at ordinary temperature. The germinating energy should be at least 70 per cent.

The germinating capacity remains undeveloped in barley fresh from the harvest if it has not been in storage. It is weakened or destroyed in barley where the germ end is hollow, or the tip brown, if the barley has become heated or moldy.

9. Bushel Weight. A barley from which a large amount of extract can be obtained will, as a rule, possess a high weight *per bushel, fluctuating* between 45 and 53 pounds, and averaging *48.6 pounds (Scientific* Station, Wahl & Henius, Chicago). How-

ever, a glassy, stubborn barley or one where the tips have been broken, a strongly albuminous barley, or one containing unusual quantities of water, any of these may weigh much more per bushel than a good, mealy and dry barley.

10. Dryness. Barley should be dry enough. It should raise dust when transferred into another vessel or when a bag is emptied. To the hand it should feel like dry sand.

VALUING BARLEY BY CHEMICAL ANALYSIS.

The chemical analysis of barley has to do mainly with ascertaining the percentage of moisture, starch, albuminoids, mineral substances and sulphur.

ANALYSIS OF AMERICAN BARLEYS ACCORDING TO UNITED STATES DEPARTMENT OF AGRICULTURE.

	Weight per Bushel, Pounds.	Weight of 1,000 Kernels, Ounces.	Moisture, Per Cent.	Albuminoids, Per Cent.	Oil, Per Cent.	Crude Fiber, Per Cent.	Ash, Per Cent.	Carbohydrates, Per Cent.
California	49	1.65	10.35	8.58	2.22	5.15	2.47	71.23
Illinois	54	1.75	11.60	8.96	2.14	4.05	2.34	70.97
Indiana	56	1.20	11.47	10.33	2.05	5.62	2.52	68.01
Kansas	....	1.12	11.57	11.73	1.93	5.07	2.95	66.75
Michigan	58.5	1.72	9.35	13.83	2.19	1.85	2.44	70.34
Minnesota	....	1.57	9.24	12.78	2.42	4.55	2.64	68.37
New York	52	1.44	11.65	10.91	2.09	3.98	2.52	68.84
Ohio	51	1.16	11.06	11.20	2.09	4.70	2.15	68.80
Pennsylvania	48	1.37	8.92	12.95	2.41	4.47	2.83	68.42
Utah	....	1.40	9.77	10.42	2.11	3.52	2.24	71.93
Washington	52	1.66	10.61	9.46	2.14	4.28	2.47	71.07
Wisconsin	52	1.14	11.72	10.85	2.27	5.17	2.75	67.24
Wyoming	....	1.44	10.32	12.08	2.23	2.00	2.24	71.13
Average for United States	52	1.48	10.80	10.69	2.13	4.05	2.44	69.89
Canada	....	1.85	11.96	10.57	2.06	4.10	2.41	68.90
Typical American barley, approximately	....	....	10.85	11.00	2.25	3.85	2.50	69.45

Moisture.—Barley contains an average of 12—13 per cent of water. The ratio changes in accordance with the ripeness of the barley, the conditions of the harvest, the manner of storage. A high percentage of moisture may cause barley to become heated in the stack, which destroys the vitality and furthermore entails a loss of dry matter and yield of extract.

2. Starch. A high percentage of starch means a high yield of extract.

3. Albuminoids. Good barley should contain the largest practicable amount of albuminoids that will be dissolved in the malting process. The average amount is about 10 per cent. A cer-

tain amount of albumen is required for developing the various enzymes and the albumen derivatives to be produced by the peptase in germinating and mashing, as proteids, albumoses, peptones and amides.

4. Mineral Substances. The amount is about 2—3 per cent. For their composition see "Constitutents of Barleycorn."

5. Sulphur. Sometimes barley is sulphured. This is not directly harmful, but always indicates that the color has suffered and is done invariably for the purpose of improving the color.

BARLEY MALT.

Barley is the best adapted of the various cereals for the production of malt, for several reasons:

1. The endosperm is covered with a husk, protecting the acrospire during the growth of the barley and serving as a filtering material in the mash-tub.

2. Barley malt contains less undesirable albuminoids (of the proteid type) than wheat malt, rye malt or oat malt; wheat malt and rye malt are without husk.

Maize malt does not enter into this consideration on account of the large percentage of oil it contains and the glassy condition of the cornstarch, which is opened up very incompletely during germination.

In judging the quality of a malt, both external marks and chemical analysis are employed.

CONSTITUENTS OF MALT.

Malt during its growth and after kiln-drying contains the following substances:

1. Carbohydrates, among which are:
    - a. Starch, to the amount of about 60 to 80 per cent.
    - b. Cellulose, to the amount of 3 to 8 per cent.
    - c. Sugars, according to O'Sullivan, saccharose 2.8 to 6 per cent, maltose 1.3 to 5 per cent, dextrose 1.5 to 3.5 per cent, levulose 0.7 to 1.5 per cent.
    - d. Gummy substances, the same as in barley. Düll was unable to find dextrin which is generally supposed to be contained in malt (Chemiker-Zeitung, 1893, p. 67).

2. *Nitrogenous* bodies, 8 to 14 per cent, of which about one-half *dissolves in the mashing* process, the other half remaining in the *grain. Of the amount* dissolved during mashing about three-fifths

is dissolved by enzymatic action (peptase) while two-fifths is ready formed in the malt. These soluble albuminoids are proteids, albumoses, peptones and amides. The amides include hypoxanthin, guanin, and vernin, all three found by Ullik, whereas the presence of xanthin is problematical, and asparagin was found only in the germs. Betain and cholin were found by E. Schulze and S. Frankfurt in the germs of barley and wheat malt (Ber. d. deut. chem. Ges., 1893, p. 2151). Besides these there are small quanti-

MALT ANALYSIS, FROM 1,741 MALTS EXAMINED AT THE LABORATORY OF WAHL & HENIUS, CHICAGO.

	Maximum.	Minimum.	Average.
Water	11.50	3.25	6.37
Extract	74.78	60.32	68.24
Extract in dry matter	79.60	64.92	73.51

MALTS (1,741) EXAMINED DURING ONE YEAR, BY MONTHS.

	Number.	Maximum.			Minimum.			Average.		
		Water.	Extract.	Extract in dry matter.	Water.	Extract.	Extract in dry matter.	Water.	Extract.	Extract in dry matter.
October	169	10.00	73.05	78.13	3.75	61.03	64.92	5.81	68.27	72.45
November	261	10.00	74.20	79.36	3.25	63.56	67.22	6.23	69.11	73.70
December	211	10.50	73.69	78.78	3.50	64.68	70.32	6.25	69.85	74.51
January	239	10.00	73.66	77.54	3.75	60.32	64.25	5.83	69.29	73.58
February	170	11.25	73.23	79.60	3.75	62.23	67.56	5.67	69.47	73.42
March	136	9.75	74.78	78.72	4.00	67.00	71.63	5.89	70.20	74.65
April	127	11.50	72.43	76.83	4.00	64.79	70.42	6.54	68.93	73.78
May	68	10.00	72.52	77.56	4.25	64.67	71.07	6.55	69.18	74.03
June	93	11.25	72.55	77.05	4.25	63.35	68.12	7.25	67.86	73.17
July	87	11.50	72.96	76.75	3.75	62.18	69.27	7.13	67.88	73.08
August	99	9.75	72.75	76.47	4.00	64.20	69.95	6.84	68.12	73.13
September	81	10.25	72.98	76.22	4.00	61.88	67.63	6.44	67.98	72.64

ties of other nitrogenous bodies, as ammonia and amido-acids, among which are leucin and tyrosin.

3. Fat to the amount of about 2 per cent.

4. Acids: Such as volatile and fixed organic acids and primary phosphates. (See Barley.)

5. Mineral substances. (See Barley.)

6. Moisture, the amount varying from about 45 per cent in steeped barley to about 1 per cent in a high kiln-dried malt.

7. *Enzymes, such as* diastase, peptase, cytase, glucase.

8. Besides these, the kiln-dried malt contains caramel which is formed on the kiln, probably out of levulose, and high-dried malts contain assamar, also formed from sugar, which has a bitter taste. Ehrich (Der Bierbrauer, 1893, p. 465), and Munsche (Wochenschrift f. Brauerei, 1893, p. 739), discovered a substance in a caramel malt that gives a similar reaction to salicylic acid, which later received the name of maltol from Brand (Zeitschrift f. d. ges. Brauwesen, 1893, p. 303).

CHARACTERISTICS OF A GOOD MALT.

1. Uniform size and shape.

2. Light color of husk and endosperm.

3. Purity, that is, absence of damaged corns, oats and other seeds, or germs, and other foreign matter. There should be no mold.

4. Sweet aromatic odor. By breathing upon a handful of malt the odor is brought out stronger. There should be no musty odor.

5. Uniform growth of the acrospire. In about 90 per cent of the corns the acrospire should be three-quarters the length of the corn. A strong growth of acrospire causes uniform mellowness and high diastatic power.

6. Proper condition of endosperm. The corns should be mellow, that is, not hard, the latter state indicating a condition of glassiness or half-glassiness. They should be easily cut with the finger nails, leave the husk readily and crack when bitten. The interior should be a fine white and have an aromatic taste. Glassy corns are caused by insufficient dissolution of the mealy part or by hasty raising of the temperature in the kiln with a high moisture percentage in the grain. A properly dissolved, mellow, malt will float in water. The undissolved glassy corns will sink and lie flat on the bottom, those insufficiently dissolved and half glassy will stand upright on the bottom.

7. High percentage of extract. The laboratory yield averages 68 per cent, but in practical brewing operations it is from 1 to 4 per cent less. The percentage of extract depends upon the type of barley used, the degree of dissolution, the kilning and the water percentage. (A comparison of yield of extract of different malts is possible only by expressing the extract as dry *matter.) A good, mellow* malt will yield a high percentage of *extract. An excessive* growth of the acrospire and radicle in-

volves a loss of extract; also an excessively high finishing temperature in the dry-kiln.

8. Sufficient diastatic strength. If the diastatic strength of a malt is deficient, slow saccharification in the mash will follow, and starch turbidity may result. Malt with high diastatic strength will saccharify quickly and worts produced from such malts will consequently contain too much sugar. American malt, as a rule, is much stronger in diastase than German malt. Pale malts will saccharify quicker than dark ones. The time of saccharifcation of American malts in laboratory tests is about four minutes after the mash has reached the final temperature. (Scientific Station, Wahl & Henius, Chicago.)

9. The percentage of water should not be too high. A damp malt is apt to acquire a musty odor when in the bin and to transmit it to the wort. Damp malt should, therefore, be used as speedily as possible. Also, the higher the water percentage, the less the yield of extract. The water in a malt fresh from the kiln is 2.5—4.5 per cent, according to the final temperature. It increases while in storage and after two months reaches about 5—6 per cent.

10. Bushel weight. This is dependent upon the nature of the barley, the degree of its dissolution, the percentage of water. A well dissolved malt in general has a small bushel weight. A high water percentage increases the bushel weight. In buying and selling malt the bushel weight is taken at 34 pounds with sprouts and 33 without sprouts.

WHEAT, WHEAT MALT AND ROLLED WHEAT.

There are varieties and subvarieties of wheat, which are distinguished chiefly by the color of the grain. As distinguished from barley, the wheat corn is bare, that is, unprotected by detachable spelts.

VALUING WHEAT.

In estimating wheat the considerations are similar to those for barley. The grain should be uniform, with a fine husk, light yellow, not brown or reddish, free from admixtures, and with plenty of meal. If on biting the berry, the fracture appears clear and horny, the corn contains too much albumen and a low percentage of starch, and is not suitable for the production of a good malt.

USES OF WHEAT IN BREWING.

In brewing, wheat is used to a very limited extent in the malted condition for the preparation of weiss beer and in rare cases for lager beer. The reason why so little of it is used is the high percentage of deleterious albuminoids it contains which make it impossible to prepare from it a brilliant and stable beer.

The wheat corn being bare will steep more quickly, and the acrospire, not being protected by a strong husk, is exposed to injury by breakage and other injurious influences on the malting floor. Wheat requires extra care in malting for these reasons.

Rolled wheat, also, is used only in a very limited degree. Wheat need not be opened up by steaming and boiling, but simply by rolling. Owing to the high percentage of noxious albuminoids in wheat flakes they cannot be added to the mash, like corn flakes, etc., but the albuminoids must have an opportunity to be eliminated. (See Mashing Process.)

COMPOSITION OF WHEAT (KOENIG).

	Moisture.	Albuminoids.	Ether Extract.	Crude Fiber.	Ash.	Carbohydrates.
Samples of miscellaneous origin (428)...	13.37	12.51	1.70	2.56	1.79	68.01
Samples from northeast and middle Germany (90)...	14.01	10.93	1.65	2.12	1.92	70.01
Samples spring wheat (81)...	14.75	11.23	2.03	2.26	2.52	68.61
Samples from south and west Germany (52)...	13.18	12.29	1.71	2.82	1.85	67.96
Samples spring wheat (30)...	13.80	14.85	1.56	....	2.19	67.93
Samples from Austria-Hungary (18)	11.72	12.60	1.90	3.39	1.75	68.84
Samples from Russia—spring wheat (39).	12.65	17.65	1.58	....	1.66	65.74
England (22)...	13.41	10.90	1.86	2.90	1.67	69.21
Scotland (16)...	11.37	10.58	1.73	....	1.55	72.77
France (70)...	15.20	12.64	1.41	2.	1.66	68.92
Denmark (4)...	13.95	9.36	2.34	2.19	1.34	71.40
Spain (9)...	13.37	12.45	1.92	....	1.80	....
Africa (34)...	11.80	11.18	1.83	1.82	1.76	70.04
Asia (8)...	12.57	11.09	2.10	1.94	1.46	70.84
Australia (4)...	13.37	10.16	1.39	....	....	.....
North America (504)...	9.92	11.60	2.07	1.70	1.79	69.74
North America—spring (40)...	9.36	12.92	2.15	1.72	1.86	67.98

COMPOSITION OF WHEAT MALT. (LABORATORY OF WAHL & HENIUS.)

Water .... 7.44 per cent.

Extract .... 74.21 per cent.

Extract in dry matter............... 80.11 per cent.

COMPOSITION OF WHEAT FLAKES. (LABORATORY OF WAHL & HENIUS).

Average of Nineteen Analyses.

Water ....11.16 per cent.
Oil .... 1.83 per cent.
Extract ....72.50 per cent.
Extract in dry matter................81.62 per cent.

RYE, RYE MALT, RYE FLAKES.

The use of rye in the malted or rolled form for brewing is still less extensive than that of wheat. Rye malt is used extensively in distilling, and pressed yeast manufacture. The objections to rye malt and rye flakes are the same as those to wheat.

COMPOSITION OF RYE (KOENIG).

	Moisture.	Albuminoids.	Ether Extract.	Crude Fiber.	Ash.	Carbohydrates.
Miscellaneous (173)	11.15	10.81	1.77	1.78	2.06	70.21
Spring Rye (11)	12.00	12.90	1.98	1.71	1.93	68.11
North Germany (27)	14.84	11.01	1.70	2.17	1.97	69.78
South Germany (36)	12.31	12.04	1.98	2.73	1.91	67.97
Sweden (3)	14.29	8.50	2.29	1.47	2.11	71.34
All Germany (63)	13.37	11.52	1.84	2.45	1.94	68.88

COMPOSITION OF RYE MALT. (LABORATORY OF WAHL & HENIUS.)

Average of Three Analyses.

Water .... 7.12 per cent.
Extract ....70.25 per cent.
Extract in dry matter................82.08 per cent.

OATS.

Oats are used both raw and malted, but only to an insignificant extent, in the preparation of certain beers of local vogue in Germany. The use of oats for brewing is quite unknown in the United States.

Oats have spelts like barley, but the husk is coarser, containing more cellulose. The husk contains matters of an offensive taste, which must be eliminated by steeping.

The large amount of spelts making oats a good filtering material, they may be successfully used under some circumstances as an admixture to the mash, in case the wort drains off poorly. To this end *the oats* are first steeped in water and then dried *before going into the mash.*

Worts made from oats foam a good deal and are turbid from the high percentage of albuminoids hard of elimination. The same is true of the beers made therefrom. Fermentation is stormy.

COMPOSITION OF OATS (KOENIG).

	Moisture.	Albuminoids.	Ether Extract.	Crude Fiber.	Ash.	Carbohydrates.
Miscellaneous (377)	12.11	10.66	4.99	10.58	3.29	58.37
Middle and North Germany (31)	12.45	10.82	5.30	10.25	3.29	58.23
Southern and Southwestern Germany (16)	13.39	11.36	5.30	9.93	3.18	58.12
Austria-Hungary (14)	11.85	11.41	5.84	11.01	3.23	56.40
France (196)	13.50	9.52	3.46	9.18	3.26	62.47
United States (22)	12.11	10.11	6.24	9.33	2.99	58.61

CORN AND RICE.

The extract of the wort and consequently of the beer being derived principally from the starch of the goods used in the mash, it readily suggested itself to use, besides barley malt, other materials which contained larger quantities of this important ingredient. Owing to its exceptionally high percentage of starch, which is greater than in any other cereal, rice seemed peculiarly suitable for brewing and was so employed at an early date.

Corn and rice are not malted like barley. Rice is used in its original form as a raw cereal, having only been stripped of the outside husk and broken up, while corn is degerminated. Both cereals differ from barley malt not only by their high starch percentage, but also by containing a much smaller quantity of albuminoids, and by their white color, for which reasons they are peculiarly suitable for the preparation of pale, sparkling and stable beers.

Corn and rice must never be used without a certain percentage of malt, and furthermore, require special treatment before getting into the mash for the following reasons: Having failed to go through the process of germination they lack those enzymes which are necessary for modifying starch and albuminoids, of which enzymes, on the other hand, malt contains such an excessive amount that it is enabled to modify a considerable quantity of additional starch. Moreover, the mealy body of rice and corn, ich contains the starch granules has a much firmer structure

than barley malt, which has been loosened by germination, and for that reason is not subject to modification by the malt diastase into soluble bodies, as dextrin and sugar. It is necessary to cook the rice and corn for some time before taking them into the mash in order to gelatinize the starch and make it accessible to diastase.

VALUATION OF RICE.

To be suitable for brewing, rice should answer the following requirements: It should have a white color, a pure taste and odor free from rancidness or mustiness, and contain but little oil. An abnormally high percentage of oil generally betrays adulteration with corn, which is easily detected. The moisture should not be high, i. e., not exceed 13 per cent, a higher percentage of moisture naturally implying a diminished yield of extract, besides making the goods more liable to spoiling by heating in the sack, or by mold, etc. The yield of extract should be as high as possible.

COMPOSITION OF BREWING RICE (LABORATORY WAHL & HENIUS).

Average of thirty samples.

	Water.	Oil.	Coarse.		Ground.	
			Extract.	Extract in dry matter.	Extract.	Extract in dry matter.
Maximum.....	14.5 %	0.59%	....	....	....	....
Minimum......	11.90%	0.26%	....	....	....	....
Average........	13.21%	0.38%	78.69%	91.90%	80.05%	93.62%

CORN AND CORN PRODUCTS.

Maize, Indian corn, or "corn," for short, which is far richer in starch than barley, though not in the same degree as rice, was first used for brewing after being put through a process of germination, i. e., in a malted condition. When it was found, however, that beer prepared from it possessed a disagreeable, coarse, scraping taste, the use of corn for brewing was given up until means were found to eliminate the disagreeable taste. At the present time corn, or products prepared therefrom, is used extensively in brewing, particularly in the United States.

The cause of the coarse taste referred to was found to be the high *percentage of oil* contained in unprepared corn, only part

of which was removed by germination. This oil, of which raw corn contains 4—5 per cent, is stored principally in the germ and the cells lying close under the husk. With the removal of germ and husk, therefore, the oil is for the greater part removed from the corn. The oil by itself is of yellow color and upon exposure to the air is extremely liable to turn rancid, acquiring an offensive odor and taste.

The oil is removed in specially designed machines, where by means of revolving knives the germs and husks are separated from the grain and carried off by blowers from the mealy body, which is broken up into lumps and is then "hominy." The hominy is ground up and put on the market in various degrees of fineness, being called respectively coarse grits, fine grits, meal or flour. The only variety of corn suitable for brewing is the white one, known as flint corn, both because of its light color and the low percentage of undesirable albuminoids, as compared with other varieties of corn which are more or less highly colored.

On the whole, the coarser products, as coarse grits, have a less percentage of oil than the finer ones, as meal, and also yield more extract. Hence they are in every respect preferable to the finer products. This appears clearly from the subjoined table.

COMPOSITION OF CORN AND CORN PRODUCTS. (LABORATORY OF WAHL & HENIUS, CHICAGO.)

	White flint corn.	Coarse grits.	Fine grits.	Meal.	Flour.	Husks and germs.
Water	14.20%	12.00%	12.50%	12.50%	12.50%	14.50
Oil	4.81%	0.75%	1.04	1.92	3.04	9.19
Starch and other carbohydrates	66.19%	78.42%	77.11	75.79%	72.55	53.92
Albumen	9.54%	7.60%	7.40	7.50	8.32	9.27
Ash	1.50%	0.45%	0.63	0.73	0.91	3.00
Coarse fiber	3.70	0.78	1.32	1.56	2.65	10.12

The higher percentage of oil in the finer products is explained by the fact that in the separation of the different grades of fineness small particles of the germ and the husk pass through the sieves and remain in the finer corn products, increasing the oil percentage in them.

VALUING CORN PRODUCTS.

Irestimating the value of corn products for brewing purposes simar considerations prevail as in the case of rice. The quality is jdged principally by the oil and water content. The latter shold not exceed 13 per cent, for the same reasons that apply to rice. Corn products having more than 15 per cent of water shold not be stored longer than a week, because otherwise the cor goods may become lumpy or moldy.

Spposing a medium percentage of water, the quality of grits and meal is estimated by the oil percentage as follows:

0.05—0.5 per cent, excellent.
0.5—1.0 per cent, very good.
1.0—1.5 per cent, good.
1.5—2.00 per cent, medium.
2.0—2.5 per cent, inferior.
Over 2.5 per cent, not to be recommended for brewing purposes.

CORN FLAKES.

Grits and meal require similar treatment to rice, owing to the seely condition of the starch, i. e., the starch granules must be gelatinized.

In order to avoid cooking grits and meal in the brewery, which nvolves expense for apparatus, coal, time and labor, corn is also prepared in other ways, dispensing with cooking and enabling the brewer to use the corn directly in the mash tub without preliminary treatment. These products which may be comprehended under the name of "flakes" are put upon the market under different titles, as "cerealine," "quick malt," "frumentum," "barlyne," "coralline," "crystal rice," "maizone," etc. All these articles are prepared from grits or meal by steaming, rolling and drying, whereby the starch is made soluble. On the whole, the oil percentage is about like that found in grits of good quality. The following table gives the average composition of corn products, as grits, meal and flakes, according to the records of the laboratory of Wahl & Henius:

COMPOSITION OF CORN PRODUCTS.

	Maximum.	Minimum.	Average.	
Water	17.50%	6.50%	12.53%	656 analyses
Oil	3.92%	0.34%	1.33%	
Extract	82.26%	69.10%	76.29%	60 analyses
Extract calculated as dry matter	95.47%	73.70%	86.52%	

AVERAGE COMPOSITION OF GRITS, MEALS AND FLAKES, ACCORDING TO WAHL AND HENIUS.

	Moisture.	Oil.	Extract.	Extract in Dry Substance.
GRITS—				
Average of 50 analyses...	12.70%	0.95%	....	....
MEAL—				
Average of 25 analyses...	12.12%	1.60%	....	....
FLAKES—				
Average of 25 analyses...	11.07%	1.04%	82.03%	92.21%

ANALYSES OF MAIZE (INDIAN CORN), RICE, WHEAT, RYE AND OATS (AVERAGE).

	Weight per Bushel, Pounds.	Weight of 1,000 Kernels, Ounces.	Moisture, Per Cent.	Albuminoids, Per Cent.	Oil, Per Cent.	Crude Fiber, Per Cent.	Ash, Per Cent.	Carbohydrates, Per Cent.
MAIZE—(Indian Corn).								
Average, United States...	58	13.75	10.93	9.88	4.17	1.71	1.36	71.9[illegible]
Typical American Corn, approximately..........	......	13.40	10.75	10.00	4.25	1.75	1.50	71.75
RICE—								
Unpolished (foreign).....	......	0.87	11.88	8.02	1.96	0.93	1.15	76.05
Polished (foreign)........	......	0.76	12.35	7.00	0.27	0.40	0.46	79.51
Polished (domestic)......	......	0.67	12.20	9.45	0.10	0.40	0.33	77.52
Typical hulled unpolished, approximately...	......	0.98	12.00	8.00	2.00	1.00	1.00	76.00
Typical polished, approximately...........	......	0.78	12.40	7.50	0.40	0.40	0.50	78.80
WHEAT—								
Average, United States...	60	1.36	10.62	13.23	1.77	2.36	1.82	71.18
Typical American, best quality, approximately.	......	1.35	10.60	12.25	1.75	2.40	1.75	71.25
OATS—								
Average, United States...	40	1.03	10.06	12.15	4.33	12.07	3.46	57.93
Typical American, approximately...........	......	1.06	10.00	12.00	4.50	12.00	3.50	58.00
RYE—								
Average, United States...	57	0.88	10.62	12.43	1.65	2.09	1.92	71.37
Typical American, approximately...........	......	0.88	10.50	12.25	1.50	2.10	1.90	71.23

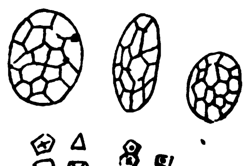
STARCH.

Starch occurs very commonly in nature, being a constituent of nearly all plants, more especially the seeds, bulbs, roots, etc. Commercial starch is obtained chiefly from cereals and potatoes, rice and corn being especially rich in this substance.

Starch consists of granules which assume various shapes in the

Oat Starch. 400:1. Wheat Starch. 300;1.

different plants from which the starch is derived, and are round, elongated or rod-shaped, the form being characteristic of the several kinds of starch. (For barley starch see "Barley" and "Malt.")



200:1. Potato Starch. 350:1. Rice Starch. 400:1.

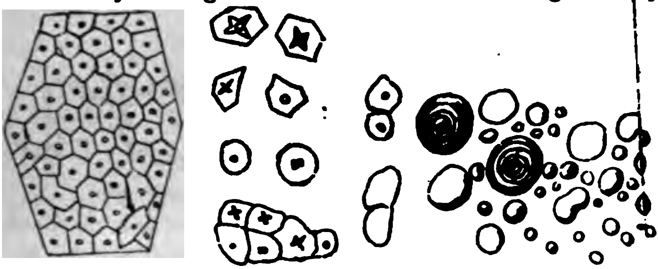
CORN STARCH.

The same considerations that led to the introduction of rice and corn or corn products in brewing also caused the attempt to be made to use starch pure and simple. The attempts were not successful to a sufficient degree to allow starch to become a brewing material in general use. Of late, however, a starch, which is distinguished by great purity, has been put on the market which must be considered in every way suitable for brewing, especially for pale, stable beers, according to a method elaborated in the Experimental Brewery of Wahl & Henius, Chicago.

A sample was analyzed with the following result by Wahl and *Henius:*

Moisture	10.07 per cent.
Albuminoids	0.16 per cent.
Mineral substances	0.13 per cent.
Oil	0.03 per cent.
Cellulose	0.20 per cent.
Starch	89.36 per cent.

This analysis shows the starch to contain scarcely any o at all and only an insignificant amount of albumen. It gives a ry



Corn Starch. 350:1. Barley Starch. 250:1.
Starches—(From Lehrbuch d. Bierbrauerei.—Carl Michel.)

high yield of extract. These three points are the decisive ones in estimating the value of a material for brewing.

Although it offers comparatively little resistance to the action of diastase it is necessary, nevertheless, to gelatinize this starch by cooking before adding it to the mash. A much shorter time is required for cooking, however, than is the case with other corn products.

BREWING SUGARS.

The necessity of cooking the most common corn products, grits and meal, in special vessels before mashing, which drawback is elsewhere pointed out, led to the preparation and introduction of other articles that require no preliminary opening up and do not even need to undergo any modifications in the mash. They represent, as it were, a concentrated wort extract, without the albuminoids, lactic acid, mineral substances, and coloring matters. These articles are the brewing sugars of various compositions. The principle on which brewing sugars of all varieties are prepared is the same in all cases. It rests upon the fact that starch *when heated in the presence* of acids undergoes a similar modification *as when exposed* to the action of diastase in the mash tub, *that is, it is converted into* dextrin and sugar.

PREPARATION OF BREWING SUGARS.

The mode of preparation, in general outline, is as follows: Corn starch—potato starch is used extensively in Germany—is heated under pressure in the presence of some acid, the mixture liquefying gradually, and the liquefied starch being converted into dextrin and sugar. The desired degree of conversion having been reached, the acid is neutralized and removed. The liquid is decolorized by suitable means, if necessary, and evaporated to the consistency of a syrup. If it contains little or no dextrin in proportion to the sugar formed—which ratio can be regulated by heating longer or shorter periods of time with acid—this syrup will crystallize when cooling and form the so-called "crystallized anhydrous grape sugar." If some dextrin remains, ordinary grape sugar or climax with approximately 10 per cent of dextrin is obtained. In the event of a large quantity of dextrin remaining the liquid cannot be crystallized and is put on the market in the form of glucose syrup or Brewers' Extract.

The difference in composition of the different types of sugar will appear from the following analyses made in the Laboratory of Wahl & Henius, Chicago:

COMPOSITION OF BREWING SUGARS.

	Extract.	Dextrose.	Dextrin.	Water.
Glucose 41	78.20%	39.77%	38.43%	21.80%
Glucose 42	80.32%	37.82%	42.50%	19.68%
Grape Sugar 70	83.28%	71.02%	12.26%	16.72%
Grape Sugar 80	89.10%	79.20%	9.90%	10.90%
Standard Climax	89.70%	78.07%	11.63%	10.30%
Brewers' Extract	80.00%	30.00%	50.00%	20.00%
Crystallized Anhydrous Grape Sugar	95.45%	94.05%	1.05%	4.55%

USE OF BREWING SUGARS.

The various sugars, with the exception of "climax," are especially adapted for the preparation of very pale, stable beers, on account of their light color, or rather lack of color, and the total absence of albuminoids. Climax is used particularly in brewing ale and porter. Anhydrous grape sugar, besides the use already referred to, is, according to tests by the Scientific Station for Brewing of Chicago, especially suited to the preparation of sugar kracusen.

VALUING BREWING SUGARS.

The characteristics of a good sugar are the following: As far as the solid sugars are concerned—except Climax—they should have a white color, the liquid ones should be without color (glucose syrup, brewers' extract). They should give a clear solution in water and possess no constituents that could cause beer turbidity, such as imperfectly converted starch, and should be free from iron.

HOPS.

Hops as they are used in the brewery are cone-shaped formations, representing clusters of blossoms of the female hop plant. From 40 to 60 flowers are grouped together on a central spine, which is zig-zag shaped, forming a so-called hop cone or the umbel of the hop. The blossoms are protected externally by bracts, to the lower end of which in a slight fold are attached the blossoms proper and later the fruit or seeds. Male and female blossoms are distributed on separate plants. Only the female hop is cultivated, the growth of male hops being, with rare exceptions, avoided in order to prevent seed production. The plant is propagated by cuttings.

At the time of maturity, the seed of the hops and the whole lower and inner parts of the bracts are covered with a fine light yellow dust consisting of minute granules. It is called hop meal or lupuline.

The fruit or seeds are scarce in good hops, small, shrunken and sterile, that is, incapable of propagating the plant. In the coarser kinds of hops the reverse is true.

HISTORY OF HOP CULTURE IN THE UNITED STATES.

Up to 1808 hop culture remained confined to three New England states, Massachusetts, Vermont and Maine. The soil of New England, however, being poor and unsuited to hop growing, the effort was speedily abandoned after a beginning was made in Madison County, in the state of New York. The hops from New York state were not only superior in quality, but three times as prolific. As a result, from 1850 to 1865 a small part of the state of New York, known as the hop region, lying south of the New York Central Railroad between Albany and Rochester, had a monopoly of hop raising in the United States. About 1860 small patches were planted to hops in Wisconsin

and Michigan, and in 1866, when the New York crop was wholly destroyed by vermin, the hop growers of Wisconsin got famine prices for their excellent product. The hop louse reached Wisconsin a short time after, and for the last twenty years Wisconsin hops are no longer quoted in the market reports.

During the decade 1870-1880 New York once more enjoyed a monopoly of hop growing. But by that time fresh competition began to develop on the Pacific Coast. Russia River hops from California were a revelation; "fine as silk" in texture, bright golden in color, "clean picked," and second only to the best German hops in "richness" or lupuline, it is no wonder that

Branch of Female Hop Flowers.
(From Lehrbuch d. Bierbrauerei.—Carl Michel.)

Female Hop Blossom.

with "Russian Rivers" in the van the hop production of the narrow California hop region should have gone up from a few hundred bales of Russian Rivers to her present 30,000 to 40,000 bales of "Californias."

In Oregon and Washington the growth of the hop industry was as sudden and remarkable as that of California. In 1866 Charles Wood, who had established a small brewery in Olympia, W. T., was raising in his garden a few hops for his own use in the brewery. In 1866 Jacob R. Meeker of Puyallup,

Washington (Territory then), obtained half a bushel of hop roots from the above mentioned Charles Wood, who had promised to buy the hops to encourage the enterprise. These roots were set out in the spring of 1866, and in the fall of that year the first crop was sold to Wood at 85 cents per pound or over $50 for a single bale of hops. It is no wonder that the culture of hops developed rapidly in the Puyallup and White River valleys of Washington and spread from there into Oregon.

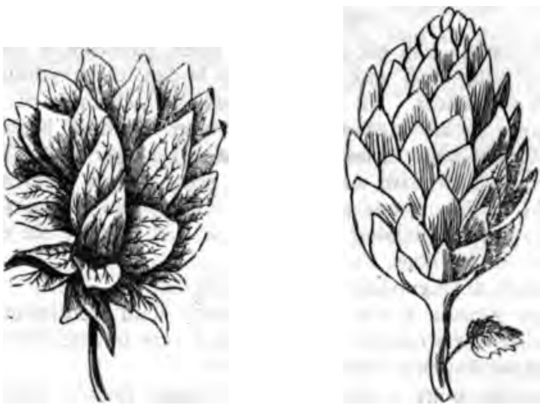
It seemed for the first twenty-five years, or up to about 1892, as if in Washington and Oregon was to be the future hop growing industry of the United States with plenty to spare for export. The hops were excellent in quality, and the rich, new soil produced enormous crops, in one or two well attested instances reaching the almost incredible yield of 4,000 pounds per acre, and with an average yield per acre of more than twice that

Branch of Male Hop Flowers.
(From Lehrbuch d. Bierbrauerei.—Carl Michel.)

of New York state. Then in 1882 hops went to one dollar and more per pound, and again in 1886 the entire crop of New York state was cut off by lice while the Pacific Coast crop was uninjured and brought a good price. Not a hop louse had as yet been discovered on the Pacific Coast, and some good judges held that no hop louse could live in that climate. But in 1892 the insect made its appearance in that part of the country, and although the growers in Washington fought the lice vigorously, the product of Washington has gone down from 40,000 to 10,000 bales within the past ten years.

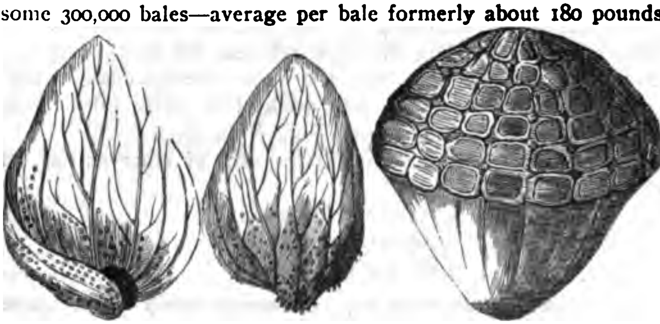
It is safe to say that now the whole territory of the United States has been tested for hop growing, and the culture of hops has settled down at last into New York state in the East, and Oregon, California and Washington on the Pacific Coast. The

pre:nt acreage of New York state will produce with a fair crop notess than 150,000 bales. With but little larger acreage it has oft in past years baled more than that. The Pacific Coast



Clusters of Female Hops at different stages of growth.
(From Lehrbuch d. Bierbrauerei.—Carl Michel.)

o-day is capable of producing on its present acreage also 150,000 ›ales. A normal crop of East and West combined is therefore some 300,000 bales—average per bale formerly about 180 pounds,



Leaves (Bracts) of the Cone of Hops. (From Lehrbuch d. Bierbrauerei. —Carl Michel.)

Lupulin Gland, according to Bersch, magnified 300 times. (From Handbuch d. Landwirthschaftlichen Gewerbe.—C. J. Lintner.)

to-day about 190 pounds net hops—or some 100,000 bales per year more than the hops required for consumption in this country with a beer production of say 36,000,000 barrels. With a no

mal export to England of 50,000 bales per year there is still left a surplus in this country of 50,000 bales per year provided all the hop sections produce each year a fair crop.

COMPOSITION OF HOPS.

Hops contain hop oil, hop resins, acids, particularly hop tannin, hop bitter, hop wax, nitrogenous bodies, carbohydrates and mineral substances. An enzyme (diastase) which is of special importance in ale brewing has also been found in hops. The oil content of hops varies between 0.2 and 0.8 per cent. The oil is highly volatile with water vapors; 600 parts of water are capable of dissolving one part of oil. If exposed to the air, the oil turns to resin, passing into valerianic acid. Hence, the cheese-like odor of old hops.

Hayduck distinguished three resins in hops:

1. The α-resin, a soft resin of thickly fluid consistency and pale reddish brown color. It possesses a very intense and lasting bitter taste, but practically no odor.

2. β-resin, quite similar to the L-resin, thickly fluid, with strong hop odor.

3. γ-resin, a solid body, brittle, dark brown, not bitter and quite without odor. The last named resin is therefore of no apparent value for brewing purposes.

The soft resins, according to Hayduck, are formed from two bitter acids contained in the hops, whereas the hard resin is a product of the hop oil. The soft resins are gradually transformed into hard ones when hops are kept in store. (Briant and Meacham, in Transactions Inst. Brg., VII., 4).

In fresh hops was found 17.984 per cent of ether extract, of which

4.734 per cent α-resin.
8.065 per cent β-resin.
5.191 per cent γ-resin.

The tannic substances of hops are stored chiefly in the leaves of the cone. According to R. Wagner (Dingler's Polytech. Journal, 154, p. 365) hops contain 3.17 to 5.1 per cent of tannic acid which differs from the tannic acid of gall-nuts, whereas Hayduck found 1.88, 2.40 and 2.65 per cent of tannic acid in the dry substance of three hops. This tannin is a pale brown amorphous powder soluble in alcohol diluted with water. The aqueous solu-

tiondisplays an intense color without a precipitate, upon an addition of iron chloride.

HOP BITTER ACIDS.

Hyduck, starting from the two soft hop-resins, obtained crystalline precipitates of different forms, suggesting the probability that hops contain two crystallizable hop bitter acids, from which the α and β-resins seem to be gradually formed.

NITROGENOUS CONSTITUENTS OF HOPS.

Among the nitrogenous bodies contained in hops, according to Pesonne, we have gluten; Griessmayer and Behrens detected triethylamin in hops. The latter showed that this substance is generated when hops become heated spontaneously. In this process a bacillus seems to play a part which Behrens called bacillus lupuliperda. In the presence of sugar this bacillus produces butyric acid.

The total amount of nitrogen in hops was found by Hayduck to be from 2 up to nearly 4 per cent, the soluble part being 0.75 to 16 per cent, or calculated as albumen 12 to 24 per cent total albumen and 4.6 to 10 per cent of soluble albumen. (Wochenschrift f. Brauerei, 1894, p. 734).

The enzyme found in hops by Brown and Morris, which is probably identical with diastase, is accumulated chiefly in the seeds.

Griessmayer found 3.7 per cent of dextrose in hops, and Brown and Morris found 1.55 per cent of dextrose and 2.10 of levulose.

The wax contained in hops is similar to beeswax and is of no importance.

According to Thausing, hops contain 5.3 to 15.3 per cent, and an average of 7.54 per cent, of ash, as derived from 26 analyses, about one-third being made up of potash and one-sixth of phosphoric acid.

J. Brand detected boric acid in the ash of the leaves, stems and twigs of the hop plant, as well as of the cone. This acid passes into the beer (Zeitschrift f. d. ges. Brauwesen, 1892, p. 426).

ACTIVE CONSTITUENTS OF HOPS.

The active constituents of the hop plant are stored up chiefly in the lupulin. Hence the value of hops for brewing purposes is largely dependent upon the amount and properties of the lupulin. These active constituents are:

1. Hop oil, which carries the aroma. The aromatic oil of hops is only slightly soluble in water, and very volatile with water vapors. In saccharine solutions—f. i., wort—it dissolves to a somewhat greater extent than in water pure and simple. It is readily soluble in alcohol and petroleum ether.

2. Hop resin, which imparts the bitter taste, and by virtue of its germicidal action contributes to the stability of beer. There are three hop resins, two soft and one hard. The soft resins only possess the valuable properties. If hops are kept stored away, especially if the conditions are unfavorable, the valuable resins are apt, under the influence of the air, to be transformed into the worthless hard resins. Hop resin is not readily soluble in water, more readily in saccharine solutions, as beer wort. If the sugar of the wort is consumed in fermentation, the hop resin is gradually precipitated, the fluid being no longer able to keep all of it in solution.

3. Hop tannin, which like all kinds of tannin, causes certain albuminoids to be precipitated and thus promotes the coagulation of the albuminoids when the wort is boiled with hops. The tannic acid is contained chiefly in the bracts.

VALUATION OF HOPS.

The valuation of hops is based almost wholly on external marks, the following ones being decisive:

1. Luster and Color. Fine hops possess a silky luster which is absent in inferior grades. The color is a greenish yellow, varying with the origin of the hops and being characteristic for the same. Thus, New York hops show a somewhat paler color of a stronger greenish shade, whereas Pacifics have a more decidedly yellowish color. A reddish tint may indicate that the hops were left on the poles too long before being picked, or that they became heated in the package, which is far worse, as it implies a darker coloration of the lupulin and deterioration of the aroma, which means a general deterioration of quality. Inasmuch as this discoloration begins in the middle of the bale, all hop samples ought to be taken from that part. Occasional red spots indicate exposure of the plant to hail and do not detract from the value of the hops.

2. Form and size of the cones. These features also are characteristic of the origin of the hops. On the whole, small cones are preferable to the big ones, as they average higher in lupulin.

The bracts ought to lap over one another and hold firmly together, whereby the lupulin is kept better. Hops with few and small seeds are preferred.

3. **Odor.** Hops should possess a strong, fine aroma, free from any off-smell, as odors of fruit, garlic, etc.

4. Clean Picking. There should be a minimum amount of stems, foliage, mold or stripped cones. Stems and leaves give a coarse taste to the beer.

5. **Lupulin.** There should be a maximum of this body. In fresh hops it has a light yellow color, the granules appearing smooth, shining and full under the microscope. With increasing age the lupulin takes on a deeper color, and the granules shrink. To find the lupulin, a few cones should be torn. When drawn over a piece of paper the broken cones ought to leave behind a greasy, greenish yellow line. The weaker and drier this line, the less lupulin is present.

HOP PREPARATIONS.

LUPULIN (COMMERCIAL).

The chief active constituents of hops being collected in the lupulin, it is practicable to use the latter substance for brewing instead of the whole cone. As a rule, however, only part of the hops are replaced by lupulin. The amount of tannic acid in lupulin being small—since this substance is contained chiefly in the bracts—but little influence is exerted upon the "break" of the wort. Hence the necessity of using some whole hops with the lupuline.

The valuation of lupulin is based on:

1. Appearance. It should be a pale yellow, the granules be shining, smooth and full, not shrunken, in order to show that it came from fresh hops and is well preserved.

2. Aroma. It should be strong and fragrant, to show the lupulin to come from high-grade hops.

3. Ash. While perfectly pure lupulin contains about 5 per cent of ash the commercial article shows a considerably higher amount, about 12 to 15 per cent, caused by sand which, with the lupulin, falls from the hops during the drying process. A higher percentage indicates that sand was added purposely, in order to increase the weight fraudulently. The amount of sand may also be shown microscopically.

4. *Adulterations.* Besides the adulteration with sand, tannic

acid is sometimes added, which may be easily shown by chemical analysis.

HOP EXTRACT.

The oil and resins can be easily extracted by petroleum ether or naphtha without undergoing any material changes. Not so the tannin, which is insoluble in the solvent mentioned. The petroleum ether extract is concentrated to a syrupy consistency, high temperatures being avoided on account of their deleterious influences upon the various constituents. This article is the hop extract of the trade. It has the advantage over whole hops of containing the most important constituents of the latter in a concentrated form, taking up very little room, and, if packed in air-tight vessels, retaining its properties indefinitely without undergoing any change.

Only a portion of the hops should be replaced by extract.

The composition of hop extract appears from the following analysis, made at the Laboratory of Wahl & Henius, Chicago.

COMPOSITION OF HOP EXTRACT.

Volatile oil and loss by drying	5.94
Soft resin	84.36
Hard resin	4.44
Wax	1.83
Tannic acid	Trace
Nitrogenous matter	None
Insoluble in ether and alcohol (cellulose, etc.)	3.43

COLORANTS.

For preparing a beer of dark color a malt may be used which has been subjected to special treatment in the kiln so as to acquire a dark color. In a great majority of cases, however, certain materials are used, which possess high coloring power, enabling their use in small quantities, along with the usual materials. Such matters are used both in a solid and in a liquid state.

Those used in a solid state are:

CARAMEL MALT.

This is a malt prepared according to a special process. The husk of this malt is yellowish brown, while the endosperm has a decided brown color. In its preparation, ordinary malt of good quality is steeped for a while, so as to take up a certain amount of moisture. It is then dried, and heated in suitable vessels, first to a comparatively low temperature in order to promote the

formation of sugar, and later to higher temperatures at which the sugar is caramelized.

An analysis of caramel malt gave this result (Laboratory of Wahl & Henius):

Water	5.5 per cent
Extract	62.19 per cent
Extract as dry matter	65.81 per cent

BLACK MALT.

This malt is dried at higher temperatures, so that both the husk and the endosperm possess a blackish brown color. It does not have the pleasant caramel taste of caramel malt. The coloring power is very great.

Inasmuch as the amount and composition of the extract from this malt are of very little consequence, it is generally made from inferior malt.

ROASTED CORN.

It is prepared from corn in the same manner as black malt from barley, i. e., by heating to higher temperatures. Its coloring power equals that of black malt.

Of the liquid coloring materials the following may be mentioned:

SUGAR COLOR

This was formerly made by heating cane sugar, but since grape sugar was generally introduced in brewing, this article is also used for preparing sugar color. Grape sugar, which contains dextrin, or a mixture of grape sugar and glucose syrup, is heated, the water evaporates, and the grape sugar takes on first a brown color, and, heating being continued, a black color as it is charred. This product is dissolved in water and separated from the carbon parts by filtration.

MALT COLOR.

Malt Color is an extract of black malt, filtered and evaporated to a syrupy consistency.

PORTERINE.

An addition of this article to common beer is intended to impart a color and, to a certain extent, a taste of porter. Like the other fluid coloring materials, it is a brown syrupy liquid.

VALUATION OF LIQUID COLORANTS.

The *estimation* of all fluid coloring matters is based on *common viewpoint*. When added to boiling wort they sho

not interfere with the "breaking" of the wort. When added to finished beer they must not impair its brilliancy or give any burnt taste The coloring power should be as great as possible.

COMPOSITION OF COLORANTS.

The composition of the three types of fluid coloring materials is given in the following table (Laboratory of Wahl & Henius):

	Sugar Color.	Malt Color. I.	Malt Color. II	Malt Color. III.	Porter-ine.
Water	27.40%	43.75%	41.03%	30.75	27.44%
Extract	72.60%	56.25%	58.97%	69.25	72.56%
Sugar as Dextrose	37.65%	....	....	9.64	41.12%
Sugar as Maltose	....	10.52%	6.90%	....	....

VARNISH.

Wooden vessels in the brewery are varnished for the purpose of preventing any extractive matters that may remain in the wood getting into the beer. At the same time the varnish prevents the beer from penetrating into the pores of the wood, where it would sour and become a source of infection that would subsequently attack the beer run into the vessel. (See also "Varnishing.")

COMPOSITION OF VARNISH.

Varnish, in general, is a solution of pure orange shellac in pure alcohol, and should contain about 3.5 to 4 pounds of shellac per gallon of alcohol. An average of 32 analyses at the laboratory of Wahl & Henius, Chicago, shows 41.36 per cent of shellac. Varnishes containing more than 3.5—4 pounds of shellac to the gallon of alcohol should be diluted by the addition of alcohol. Formerly grain alcohol only was looked upon as the proper solvent for the shellac, wood alcohol being regarded as an adulterant, and very properly so, since it was never free from impurities, which are mostly of a poisonous nature. Recent efforts have succeeded in producing a perfectly pure wood alcohol, which is put on the market by the name of Columbian Spirits, which yield a varnish that meets requirements. Since, however, the vapors even of this highly rectified wood alcohol *may* have an injurious effect upon the health of the laborers entrusted with the work of varnishing, special care must be taken to have the vats, etc., provided with good ventilation. This recti-

fied wood alcohol being much lower in price than pure grain alcohol, varnish made from it ought also to be correspondingly cheaper.

PROPERTIES OF VARNISH.

The properties of a good varnish are the following:

1. It should dry quickly. The coat should be quite hard in about 48 hours. Varnish from wood alcohol dries more quickly than that which is made from grain alcohol. But the shellac also seems to play some part in this matter, some articles made from perfectly pure materials requiring four to five days to dry.

2. The coat of varnish should be smooth, shining, and yielding, i. e., it must be without blisters, and not crack or break off when jarred.

3. The varnish should not turn white. If this does happen, it may be due to one or more of several causes:

   a. Inferior quality of shellac.

   b. Resins in the shellac, which is not an uncommon occurrence. Shellac that is adulterated in this way is generally imported in that state.

   c. The wood of the vessel may remain green, or not perfectly dry before varnishing.

   d. The coats of varnish may be put on in too rapid succession, i. e., the first ones may not have time to dry perfectly before the next one is put on.

   e. The varnish may be either too thick or too thin.

   f. The old varnish may not have been removed completely before the fresh coat is put on.

   g. The vessels may have been filled before the varnish was strictly dry.

The three points last mentioned may also cause blisters.

PITCH.

Trade packages are internally covered with a coat of pitch for similar purposes to those which lead to varnishing storage casks, etc., i. e., to prevent the beer coming into contact with the wood.

Brewers' pitch is the purified resin of certain coniferous trees, as pines, firs, etc. This resin is extracted by cutting into the trees, when it will ooze out like sap. It is called turpentine, and *is a mixture of colophony,* oil of turpentine, water, and some other

substances not easily volatilized. To gain pitch from the crude resin, it is melted and heated, whereby the water and oil of turpentine are volatilized, while the impurities, as pieces of wood, sand, etc., either gather at the surface or settle on the bottom. Upon cooling, the mass congeals, showing a yellowish-brown to dark-brown color. This is ordinary pitch.

By continued heating all the volatile substances can be driven off, and the remaining matter is called colophony. By melting together colophony with a certain amount of resin oil, the latter being a product of destructive distillation of colophony, or else colophony and linseed oil, brewers' pitch is produced. In many cases, especially where the modern pitching machines are used, brewers prepare their own pitch in that manner. Resin oil is preferable in such cases. Cottonseed-oil has been of late used to soften colophony to advantage. It is cheaper. (See also "Pitching.")

VALUATION OF BREWERS' PITCH.

The valuation of pitch proceeds upon the following viewpoints:

1. Temperature of softening. The heat at which pitch will become soft fluctuates in very wide limits. According to 83 analyses made in the laboratory of Wahl & Henius, the extreme points are 65° F. (14.5° R.) and 103° F. (31.5° R.); average 84° F. (23° R.). Colophony softens at about 132° F. (45° R.).

A pitch that softens at temperatures up to 77° F. (20° R.) is decidedly soft, and may cause trouble. If the empty packages are exposed to the sun, which is not an uncommon thing, the pitch may run down. It should be remembered that the point of softening gradually rises as the pitch is kept hot, owing to the evaporation or decomposition of volatile substances. The point of softening rises rapidly if pitch is heated in open vessels, more slowly if in closed vessels. It is therefore impossible to give any hard and fast standard for the softening point a good pitch ought to have, since the problem is always modified by considerations of whether or not the pitch is heated before pitching proper begins, and if so, for how long, to what degree of heat—the higher the temperature, the more quickly does the point of softening rise—whether in an open kettle or a closed boiler, what is the construction of the pitching machine, if one is used, how long pitching is kept up before fresh pitch is added, whether pitch runs in continuously or not, etc.

Where pitching machines of modern construction are used in which oil is allowed to flow into the pitch, it is imperative to use a so-called high temperature pitch, i. e., one which will soften at a high degree of temperature. A high temperature pitch does not soften, in its original state, below 100° F. (30° R.).

2. Taste of Pitch. When chewed, pitch should not have an offensive taste, since such taste might be communicated to the beer, although those constituents which cause the offensive taste are driven off, for the most part, by heating.

3. Influence on Taste of Beer. Pitch that has been heated for some time and broken into small parts when added to beer should not affect the taste of the same. A taste of pure pitch is permissible, under certain conditions, where, owing to the requirements of the market, a slight pitch taste is wanted in the beer.

4. Purity. Pitch should be as free as possible from impurities, as wood fiber, sand, etc. This may be tested by treatment with strong grain alcohol, which will dissolve the pitch, whereas the impurities or fraudulent admixtures remain undissolved. If wood alcohol is used instead of grain alcohol, it will leave resin oil, tallow and animal fats undissolved, if any such should be present.

5. If diluted alcohol containing about 4 per cent of alcohol is added to a small amount of pitch, the alcohol, after 24 hours, should have no offensive odor or taste, and not affect litmus paper.

CLARIFIERS.

At the expiration of the storage period, the beer still remains more or less turbid, owing to the presence, in suspension, of dead or weakened yeast cells, albuminoids and other substances, which must be removed in order to obtain a brilliant and stable product. This clarifying is done by adding substances that act in a purely mechanical way. The two following methods are used for clarifying:

CLARIFYING CHIPS.

They consist of strips of wood of varying length, width, and thickness, that are cut by suitable machinery from wood which is easily split. Beech and maple are the woods used almost exclusively for this purpose. The length of the chips varies between *6 and* 12 inches, the thickness being about one-*twelfth of an inch* on an average. Chips also vary in form.

There are smooth chips and corrugated chips, the latter showing either a uniform wave shape or a pronounced fluted surface. Some brewers prefer smooth, straight and thick chips, while others think the thinner corrugated chips are better. Of late, metal chips, particularly aluminum ones, have been introduced. In view of the fact, however, that certain metals are known to be capable of causing turbidity, caution must be observed in using metal chips.

Only well seasoned wood should be used for preparing beer chips.

ACTION OF CHIPS.

The clarifying action of chips is a purely mechanical one. They act by superficial attraction, that is, their wide surface attracts the little suspended particles, which remain adhering to it.

It has been claimed that the chips exercise a chemical action upon the beer, also, the oxygen of the air being condensed at the surface of the chips and, passing into the beer, exercising its effect upon the yeast cells, causing them to settle more rapidly, and thereby accelerating clarification.

FININGS.

In order to clarify the beer more thoroughly a solution of animal gelatin in water is added, which is called finings. The animal gelatin, which is called isinglass, is derived from two sources, the two following kinds being distinguished:

ISINGLASS FROM FISH SOUNDS.

The swimming bladder, or sounds of various fishes, consists of glue substance, or gelatin, in more or less pure form. These swimming bladders are used in the preparation of isinglass, as it is used in brewing.

The sounds used in the various formulæ of the manufacturers, at the present time, besides the American Hake, are known as the Bombay Cake, the Maracaibo, the Russian Promislovy, Saliensky and Persian. Each kind has its pecularity, and each manufacturer a formula of his own for combining two or more kinds to meet the requirements of his own particular trade.

Not all kinds of fish produce the sound adapted to the purpose, and only one, the Hake, is found on our shores. The *Weakfish might also be* mentioned, but the quantity is so in*considerable as practically* to be omitted. The sound of the

codfish contains only about 30 per cent of gelatin, and furnishes a product of inferior quality.

PREPARATION OF ISINGLASS.

The crude stock, which is purchased dry, can be made into isinglass only in cold weather, from December 1st to April 1st. The first process, after carefully culling and washing every sound, is that of soaking and tempering, which requires from 48 to 72 hours. Only cold water is used in soaking. The sounds are then macerated and run through a series of rollers, until drawn out in continuous length they form a ribbon 8 or 9 inches in width, in a moist condition. The rollers are hollow, and ice water is continuously passed through them.

In order to facilitate the process of rolling, the first set of rollers was, in former years, sprinkled with starch, but there being a strong prejudice against it, and the starch being easily detected, the practice has been discontinued almost entirely.

The isinglass is subsequently dried, folded, and packed in cases, from 100 to 125 pounds. The products which come into the market in the form of shreds or leaves, vary in color from a deep yellow to almost white.

STORAGE OF ISINGLASS.

If properly stored, isinglass will keep for several years, but it will deteriorate in a damp storage room. If kept in a dry room, it becomes harder after the first year, dissolves less rapidly, and in time loses its strength.

ISINGLASS FROM THE HIDE OF THE CALF.

Skins of animals contain large quantities of gelatinous matter, although not in such large amounts as the swimming bladders of the fish mentioned above. This gelatinous matter is utilized in the preparation of isinglass by Wahl's process, from calves' skins. Naturally, the process is more complicated than in the preparation of isinglass from sounds. The carefully washed pieces of calf's hide are soaked for about a week in a strong solution of sulphurous acid in which they swell to about twice to three times their original size, and become quite soft. Then the stock is shredded, the acid washed out, and gelatinous matter extracted by warm water. The resulting jelly on cooling is cut, dried, and the pieces of gelatin crushed.

What was said above about storage applies here as well.

[redacted]

CLARIFYING ACTION.

A solution of isinglass being added to beer which is cold, it will coagulate into a flocculent mass, which will be finer if the original solution was thin, and coarser if the original solution was in a more concentrated form. This coagulated mass, being evenly distributed throughout the whole body of the beer, forms, as it were, a network which envelops the substances held in suspension in the beer. Then, having a greater specific gravity than beer, it gradually settles on the bottom, carrying down with it all the substances that made the beer turbid.

ANTISEPTICS.

(See also "Treatment and Protection of Surfaces.")

The dangerous enemies of the brewer, as molds and bacteria, are exceedingly resistent to injurious influences. There is, however, a number of substances, comparatively small amounts of which are capable of making microorganisms harmless. Many of these substances were in general use before it was known what part was played by the microorganisms in brewing operations. Following are the ones most generally used:

1. Milk of Lime. If burnt lime (caustic lime, calcium oxide) is mixed with water, it will split up to a powder, called slaked or slack lime (hydrate of lime or hydrated calcium oxide) accompanied by the production of considerable heat. This slack lime, which is not easily soluble in water, is mixed with water, to form milk of lime.

The burnt lime of the trade is not chemically pure. In estimating the value of it for preparing milk of lime account should be taken of the percentage of caustic lime, which is found by chemical means. There should be but small admixtures of sand or other impurities.

2. Soda. The soda used mostly for cleaning is carbonate of sodium, and it is put upon the market in a more or less pure state in the form of finely developed crystals. It is called crystallized washing soda. It should have the highest possible content of effective sodium carbonate. In chemically pure crystallized soda it amounts to a little over 37 per cent.

3. Caustic Soda. This is used extensively in about 5 per cent solution for cleaning out pipe conduits, etc. Sold in lumps. The commercial article contains about 90 per cent of effective sodium hydrate. Caustic soda is strongly hygroscopical. It melts away

gradually in the air, from which it takes up carbonic acid at the same time, thereby losing in effective strength. It should always be kept in tightly closed receptacles.

4. Chloride of Lime. This article possesses a strong, pungent odor of chlorine, which is easily taken up by wort and particularly by beer. For this reason it ought to be used only in such places as afford no opportunity for this deleterious influence to make itself felt. The quality of the product is estimated by the percentage of chlorine, to be determined by chemical analysis, which, in a good article, amounts to some 30 per cent. The action is intense, and enables the use of chlorine for the destruction not only of microorganisms, but also of insects, as weevils.

5. Sulphurous Acid and Sulphites. Sulphurous acid possesses very powerful germicidal qualities. Sulphuring for the purpose of disinfection and preservation has been practiced for a long time, f. i., in the cases of wine casks, hops, etc. In brewing operations no use was made of sulphurous acid, either by itself or in a watery solution. But of late liquefied sulphurous acid has been introduced in brewing operations, being contained in iron cylinders like liquid ammonia. By conductng sulphurous acid into water the brewer is enabled always to have a fresh solution of great antiseptic power. This is not in general use, however, the sulphites being used instead, which possess antiseptic properties in a less degree. For cleaning purposes the only salt of this class used is:

Bisulphite of Lime. This article is put upon the market only in a solution containing an average of about 6 per cent of sulphurous acid.. The content of this acid is decisive for the quality of the article. It seldom reaches 8 per cent. The solution loses its power by degrees, owing to the conversion of the sulphurous acid into sulphuric acid, which is of no value for purposes of disinfection. The odor of sulphurous acid which marks the solution is due to a slow decomposition of the bisulphite of lime, by which sulphurous acid is liberated.

For cleaning yeast, sulphites like sulphite of soda and K. M. S. may be used.

6. Acid Fluoride of Ammonia, also called Antiseptic Salt. The strong germicidal action of the fluorides, even in very *dilute solutions,* procured a rapid acceptance of them by brewers *and the above compound* enjoys a peculiar popularity, owing

the large percentage of efficient hydrofluoric acid, which amounts to 34 to 35 per cent. On account of the powerful effects of the solution on glass and metals, it should be prepared only in wooden or hard-rubber vessels. For cleaning purposes dissolve 1 pound of the salt in 40 gallons of water. The salt has this advantage, that a fresh solution can be prepared at any time, on short notice.

This solution may also be used in steep water.

7. Antinonnine. This is the potash compound of a derivative of creosote, the antiseptic action of which is well known. It is put upon the market in the form of a paste and gives a yellow solution in water. The solution gives off no odor.

Antinonnine is used for drying damp walls and damp wood, preventing and destroying mold on the walls, and stopping musty odors. To preserve walls from crumbling it is recommended to add 5 per cent of antinonnine to the mortar. For the other purposes mentioned a 1 per cent solution is sufficient. To obtain the best results this solution should be heated to 144 to 156° F. and two coats put on the surface to be protected, the second coat being applied two days after the first.

Antinonnine must never be applied to any implements that come into direct contact with wort or beer.

To clean the hands, that may have become yellow in handling the solution, wash them in water containing 2 to 5 per cent muriatic acid.

8. Formaline is a 40 per cent solution of formaldehyde in water, and is a powerful germicide. For washing vessels a solution of 1 part formaline in 1,000 parts water is sufficient, which percentage is obtained by mixing one tablespoonful of formaline in 4 gallons water. For disinfecting walls sprinkle them with this solution.

9. Benzoic Acid. A derivative of carbolic acid; forms delicate crystals and has an aromatic, characteristic odor. Used in alcoholic solution the same as:

10. Salicylic Acid. Related to benzoic acid, but odorless. Good for washing ceilings.

PREPARING AND PACKING SAMPLES FOR EXAMINATION.

Attention was directed at the beginning of this chapter *to the necessity of* using only faultless materials in the *preparation of* beer. In order to form a correct estimate of

them it is necessary, in many cases, to submit them to a close chemical or microscopical examination, such as can but rarely be performed by the brewer himself. In such cases it becomes necessary to send samples to a proper laboratory. Furthermore, in order to control brewing operations continuously, which is the only safe method to meet competition successfully, examination should not be confined to raw materials, but the products prepared from them, as well as all the articles that are employed in the brewery, the properties of which may exert an influence for good or bad on the finished beer, should also be subjected to analytical control.

In order to obtain reliable results from such examinations it is necessary not only to employ a station or analyst who is qualified and capable of meeting the requirements, but the brewery also, in sending its samples must do its share to enable the examinations to be made without unnecessary expenditure of time and trouble, reliably and promptly. If this is done, the principal beneficiary will be the brewery, since in most cases of disturbances in brewery operations severe losses can be prevented only by prompt and vigorous action.

The help which the brewery can and always should give to the station or the chemist charged with the examination, in its own interest, is a proper manner of taking samples, and a most complete, but brief, information about the samples and in what direction they are to be examined. It is often difficult and laborious to take samples in the proper way, but it is, nevertheless, indispensable, if there is a desire to secure really reliable results, without which the examination would be worse than useless. It is furthermore essential, in case of disturbances in operation, that a detailed description of the conditions prevailing are furnished so as to facilitate detection of the causes leading to the trouble. Time and money are always saved by the hearty cooperation of the brewer.

Inasmuch as many brewers are not familiar with the manner of taking samples, the most important considerations that should be observed may be briefly described.

Barley, Malt, Corn Products, Rice, Sugar.—Samples from different bags of the same lot, and often samples from the same bag, do not agree strictly. Samples should, therefore, be taken from *different places* of the bags and a considerable number *of bags, heaped* upon a clean spot on the floor, or, better still

on a sheet of paper, well mixed, and about a pound of this mixture taken and sent in for examination. It is advisable to ship the sample in a tin box or a strong, air-tight glass jar, not in a bag or paper package. Barley, malt, etc., has the property of absorbing moisture from the air with avidity, and if the sample is packed in cloth or paper, the percentage of moisture, when it reaches its destination, will not agree with what it was in the brewery. The result is that, for instance, the amount of extract will be found lower than it is in reality, materially diminishing the value of the material.

Crushed Malt.—Unless there are unusual reasons to prevent, the original malt, before being crushed, should be sent in for examination, as reliable results cannot be otherwise reached. But if, for certain reasons, crushed malt must be examined. take two pounds directly from the mill and pack it at once in a tin or glass vessel. as above indicated.

Grains. Immediately after the grains have been removed from the mash-tub, take small samples, at different places of the heap, mix and send a quart of the mixture in a clean glass jar or tin can which is closed tight.

Wort.—Just before running off the wort, take a sample from the kettle or a sample from the hop jack, fill up a carefully cleaned quart bottle with it and close it at once. It is useless to send a sample of the first wort, and wrong to take the sample after cooling and before pitching, as the wort is liable to be infected and become cloudy, making it impossible to form an opinion with regard to the cold "break." The bottles used should be cleaned most carefully. First put some common laundry soda into the bottle, fill it up with hot water and allow it to stand for about an hour. At the expiration of that time, empty the bottle, rinse out repeatedly with clean water, and, finally, before filling with wort, rinse out a few times with the wort. For closing use only new corks, after softening them in hot water, so as to remove those bodies which might cause turbidities. It should be added that samples that are taken as here directed will always, upon examination, show a lower saccharometer indication than where the wort is weighed in the cellar by the saccharometer, since evaporation takes place between the hop jack and the starting tub and the wort is concentrated, changing the ratio of extract. Such concentration, of course, is

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eliminated where the samples are taken as above directed, but in the examination due consideration is given to these facts.

Beer. As a general rule, in taking beer samples, no matter in what respect they are to be examined, care should be taken to use only perfectly clean bottles, as described for wort, and to clean the try cock thoroughly and let some of the fluid flow out, at least one quart in amount, before filling the bottles. The object is to remove any dirt that may have collected in the cock and to prevent it getting into the sample bottles.

As to the amount of the sample to be taken, it depends upon what the sample is to be examined for. If the beer is only to be examined microscopically, one pint is enough; if it is to be tested for durability at the same time, two pints should be sent. If the examination is to be chemical, it requires two quarts, and in case of a test for durability is also desired the amount to be sent should be increased to three quarts or four pints. To determine the carbonic acid in beer, two quarts should be sent. The bottles should have corks of good quality. In taking samples for the latter purpose, it is necessary first to cool the bottle with ice, attach a lead of hose to the tap, reaching to the bottom of the bottle, run the beer into the bottle carefully, and close with the cork at once, to prevent the escape of carbonic acid. The corks are best fastened with strong twine or wire.

If a sample of fermenting beer is to be taken, take it at the close of the primary fermentation, filling a pint bottle about one-quarter full, in order to prevent the bottle bursting from the pressure of carbonic acid generated in the secondary fermentation. In these cases a patent stopper bottle is preferable.

Hops.—From the center of the bale cut out a square piece about two inches thick by four inches long and wide, and pack it in a clean tin can, not in a cigar or tobacco box, the odor of which will impair the aroma of the hops. Never send the hops loose or torn into shreds; to do so will shake the lupulin from the bracts and make a critical examination difficult, if not impossible.

Air.—In taking samples of air it is of the greatest importance to use only sterilized bottles, which are supplied by the station. The bottles should never be opened, except in the room where *air is to be examined.* The hands should be absolutely clean *and the cover of the* bottle quite free from dirt. It is important t

place the cover on a clean sheet of paper. Leave the bottle standing open for an hour, close carefully and ship at once.

Water.—For chemical examination send a gallon in a clean jug or in five quart bottles that have been cleaned in the same way as for wort. Only fresh corks should be used. In sending such a sample, the origin of the water, whether from a well, river, lake, cistern, pump or hydrant, should always be indicated, and in the case of well water, the depth of the well. For microscopical examination of water sterilized bottles should be used, the same as for air, which, likewise, must be treated with the greatest care to avoid infection. Before taking the sample the water should be kept running for some considerable time. After being closed tight the sample should be packed in ice, if possible, and shipped at once. But, even if all precautions are observed, the examination will not afford a true idea of the number of bacteria contained in the water, since they multiply in transit even if the bottle is packed in ice.

Yeast.—For the ordinary examination of yeast as to purity, sterilized bottles are supplied, which must be treated with equal care as in taking samples of air. If a complete examination of the yeast is to be made, a pint bottle should be used, after being cleaned with the greatest care and treated in the same manner as for wort, rinsing it out in conclusion with hot water, so as to kill any germs that may remain in it. The bottle should, of course, be cooled down before the sample is introduced. The bottle should be filled with yeast about one eighth, and not to exceed one-fourth, and, if possible, especially where it is sent a long distance, packed in ice in order to avoid the yeast cells from becoming weakened or dying in transit. In taking the yeast sample, attention should be given to the following: The yeast having been run off from the fermenter in the usual manner, after removing the cover, it is allowed to settle in the yeast tub for some little time, then the beer standing over it is drained off, the yeast mixed with absolutely clean implements, and the amount for the sample taken from this well-mixed mass.

Coal.—In order to secure a good representative sample, take small amounts from different parts of the heap, crush the pieces down to about the size of a walnut, mix them well and spread them out on a clean, dry place, making a square heap of even height. Divide this heap into two equal parts, crush one part to about pea-size, make another square heap

as before from this part, divide it into four parts and send one of these parts, which should weigh about two pounds, to the examiner, packing it in a box. Care should be taken to prevent only the biggest pieces being picked out; a full portion of the divided heap should be sent, including the finer parts that broke off in crushing. In order to do this successfully, it is preferable to spread the coal heaps on a sheet of stout paper instead of piling them up on the floor, then remove from the paper the portions that are not to be used and leave only the parts to be used on the paper.

Boiler Compounds.—If fluid, send a pint; if solid, half a pound in a glass jar or a tin can.

Boiler Scale.—Half a pound packed in a box.

Oil (Lubricating, Etc.).—About half a pint in a clean, dry well-closed bottle.

Brewers' Varnish.—One pint in a dry, clean bottle.

Pitch.—Half a pound in a clean box or tin can. It is desirable to accompany the sample with a statement of how the pitch is treated in the brewery, to what degree and how long it is heated for pitching, whether oil is admixed, what pitching apparatus is used, etc.

Filtering Material. A quarter of a pound in a clean, dry glass jar or a tin can.

Chips. Half a pound in a clean box or bag.

Antiseptics.—If solid, send half a pound in a clean box; if liquid, one pint in a clean, dry bottle.

It is to the interest, not only of the analyst, but also, and particularly, of the brewery, to accompany the sample with a statement as to what the sample is to be examined for. It is in this respect, unfortunately, that omissions are common. The simplest way, probably, is to provide each sample with a label stating briefly the cause of sending the sample or what is to be done with it, i. e., on a beer sample, a remark like this: "Examine for carbonic acid," or, "Examine for durability," or to put any mark, letter or number, or both, on the label and give the necessary explanation in an accompanying letter. An exception is made in the case of samples of malt, corn products, rice, etc., which are to be examined only in the usual way. In all other cases, whenever the examination is outside of the regular routine or special causes led to sending the sample, a particular statement of all the circumstances is indispensable

MICRO-ORGANISMS.

(See tables pages 509, 512, 520, 521, 522.)

Micro-organisms are living beings of the simplest structure, many of which possess general practical and scientific interest by their capacity as generators of fermentation, putrefaction and infectious diseases.

By their morphological properties, i. e., their structure and growth, and their biological properties, i. e., manifestations and conditions of life, they belong to the vegetable kingdom and are classed among the fungi.

The lower fungi are divided into three classes:

1. Filamentous, or mold fungi.—Hyphomycetes.
2. Budding, or yeast fungi.—Blastomycetes.
3. Fission fungi, or bacteria.—Schizomycetes (Schizophytes).

GENERAL BIOLOGY.

Many of these consist of single cells and in that case are called unicellular. A "cell" is a bit of protoplasm, enveloped by a cell wall or membrane consisting of cellulose, similar to, but not identical with, the common cellulose of plants.

PROTOPLASM.

"Protoplasm" is a more or less viscous, tough, elastic, transparent, often granular substance. Chemically it is classed as albuminous in its nature. It is the most primitive substance yet discovered that possesses the peculiarities of animate or living as distinguished from inanimate or lifeless matter, and as far as scientific knowledge goes it is the ultimate basis or unit of all organic life. It is nature's agent for carrying on chemical decomposition and reconstruction of the most intricate character on which depends, to a very great extent, the metabolism or circulation and modification of matter which makes the activities of life throughout the world.

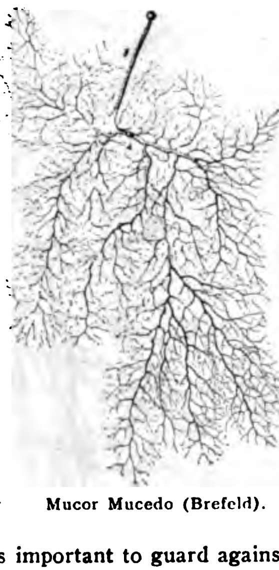
THE LIVING CELL.

The living cell is endowed with the capacity of carrying on all the essential functions of life, as respiration, assimilation, reproduction, etc. Larger and higher plants are aggregations of cells.

To the brewer, the biology of micro-organisms is of supreme importance as a large and consequential part of his work lies in dealing with their functions in making, or, at times, marring, his product. The whole process of fermentation, f. i., depends upon the cultivated yeasts for the making, upon bacteria, wild yeasts

Mucor Mucedo

Spores of Mucor Mucedo.



Mucor Mucedo (Brefeld).

and mycoderma for the marring; it is important to guard against mold in malting, etc.

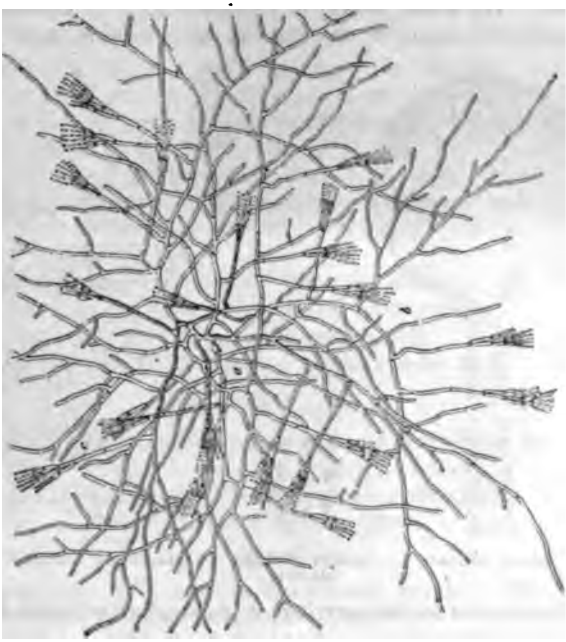
The living cell is not visible to the naked eye. It is observed by means of the microscope, a high magnifying power being required for many of its forms.

These simple plants assume a variety of shapes, some of them, like the molds, being quite complex in outline.

The cell grows by the protoplasm increasing in amount and pressing upon the cell-wall, which expands, fresh membrane matter being at the same time continuously supplied.

ASSIMILATION.

The higher plants derive their nutrition from the soil which their roots permeate, and from the air. From the soil they take up mineral substances and ammonia, from which latter substance the nitrogenous substances of the plant, like albuminoids, are built up, while from the air they take up carbonic acid, from which as a source, mainly through the agency of the chloro-

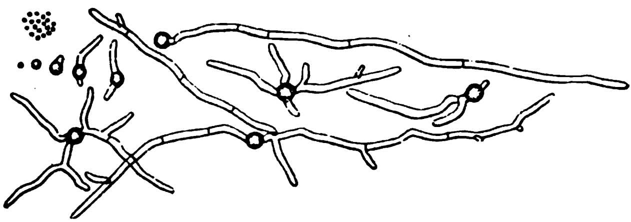


Penicillium glaucum (Brefeld) 100:1.

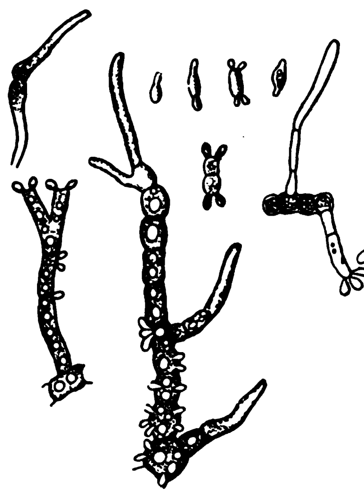
phyll cells, are produced the various carbonaceous substances, like cellulose, carbohydrates, fats, etc., that plants are composed of.

A microbe, or micro-organism containing no chlorophyll, cannot build up its body from carbonic acid, like other plants. Its food consists rather of the same substances that furnish nutriment for animal life, namely, carbohydrates, mainly in the form of

sugar; albuminoids, mainly in the form of amides; and mineral substances, mainly in the form of potassium phosphate. These substances seem to serve the same ends, moreover, in these microscopic plants as they do in the animal system, the sugar being the source of heat to supply the energy to carry on the vital



Penicillium glaucum.



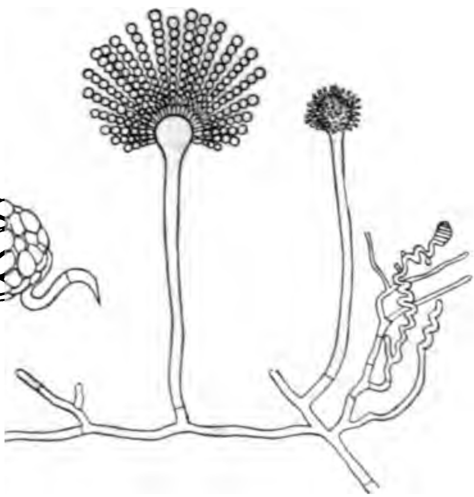
Penicillium glaucum (Thausing). Dematium pullulans (Loew) 540:1.

functions, while the albuminoids and mineral substances are the raw material from which protoplasm is produced or the body is built up.

Animals can utilize many different kinds of carbohydrates and *albuminoids for food.* These substances ultimately are changed

before they are so utilized, into the identical substances which yeast and other organisms take up for food out of a solution. Enzymes contained in the animal system change the carbohydrates, like starch and dextrin, to sugar, the nitrogenous substances, like albumen, to peptones and amides before assimilation takes place

While yeast and bacteria are capable of assimilating soluble food only, the molds thrive on starch and insoluble albumen. They secrete the corresponding enzymes as does the animal organism.



Eurotium aspergillus glaucus (De Bary).

Although amides are the principal form of nitrogenous food for yeast and probably for all bacteria, these plants can also utilize peptones and ammonia salts.

The changes that take place in the building up and breaking down of the protoplasm seem to be quite similar for animal and yeast protoplasm. At any rate it seems permissible to make such a deduction when we compare an extract of animal protoplasm with that obtained from yeast, both extracts being quite similar in composition (see "Yeast").

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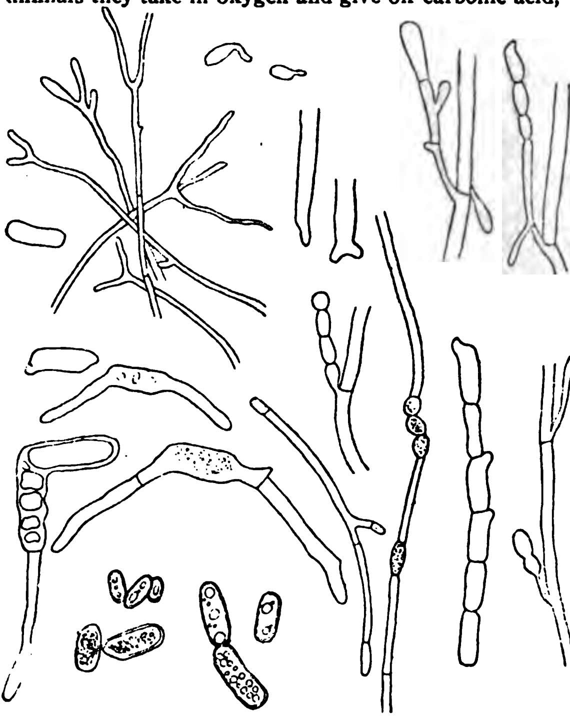
EXCRETION.

The passing out of the system, of substances that have been consumed, like broken down protoplasm, and which are thrown off as spent or of no further use to the system, is called "excretion."

RESPIRATION.

Microbes with few exceptions cannot live without oxygen. Like animals they take in oxygen and give off carbonic acid, while



Oidium lactis (Hansen) 500:1.

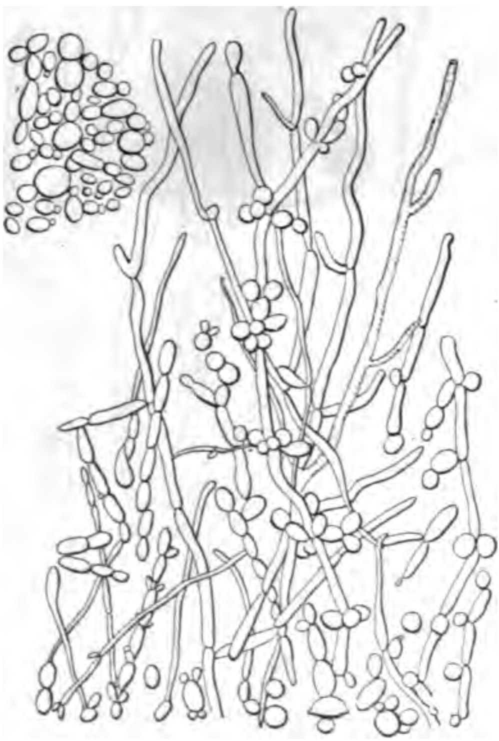
the larger plants generally take in carbonic acid and give off oxygen. The oxygen that is taken into the system combines with certain food constituents whereby heat is generated. *This generation of heat is necessary to supply the energy to perform the functions of life.*

REPRODUCTION.

Mold fungi multiply or reproduce themselves generally by sporulation, yeast fungi by budding or sporulation, bacteria by fission or sporulation (see the respective heads).

OSMOSE.

The passing in of substances, like food, from a solution to the interior of a cell, and the passing out of substances like spent



Monilia candida (Hansen) 500:1.

or broken down protoplasm from the interior of the cell to a *liquid surrounding* the cell, must take place through the mem- *brane enveloping* the protoplasm. This is a function of mem-

branes generally, whether animal or vegetable, and is called "osmose" or "diffusion." The passage of substances into a cell is termed "endosmosis," the passage out of a cell "exosmosis."

Osmose is distinct from filtration. Whereas all substances in solution will pass through a filter with the solvent, only certain substances in solution, like salts, sugar generally, and substances that will crystallize, hence crystalloids, will pass through a membrane, while others like erythro-dextrin, proteids in solution, generally uncrystallizable or colloid substances will not.

Some substances will pass through a membrane with greater facility than others, for instance, dextrose will pass through the

Bacterium termo (Sternberg) 1000:1.

Lactic acid bacteria (Storch) 500:1.

yeast cell wall quicker than maltose. Generally speaking, a substance is the more readily assimilated by a cell, the more readily it diffuses through the membrane. Where sugars are split up in the interior of a cell into alcohol and carbonic acid we may say that those sugars ferment the most readily, which diffuse through the membrane most readily.

OSMOTIC PRESSURE.

All substances in solution exert a pressure on the membrane of the cell. This pressure is consequently exerted from without as well as from within.

Different substances exert different pressures, and these pres

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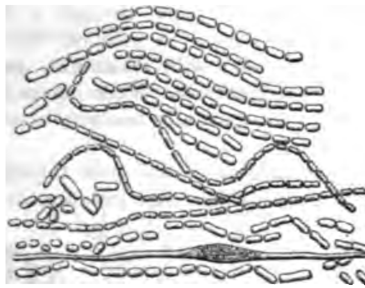
sures differ also with the nature of the membrane. Thus dextrose exerts about 30 times the pressure of erythro-dextrin, and maltose about one-half as much as dextrose. Prior (Malz und Bier, 1896, p. 457) explains the differences in the degree of

Bacterium aceti (Hansen) 1000:1.



Bacterium pasteurianum (Hansen) 1000:1.

fermentation, which different yeasts show in worts of the same composition, by assuming that the substances in solution exert different osmotic pressures on the membranes of the different yeast, like Saaz, Frohberg, Logos, the membrane of these yeasts showing differences of structure.

VITALITY.

Protoplasm shows different powers of resistance toward adverse influences, according to circumstances. If protoplasm is carefully dried it preserves its vitality for a long time, can be subjected to high degrees of heat, and exposed to intense cold without serious injury. Again, the protoplasm of spores of some bacteria and yeasts have greater vitality than the parent cell. The spores of bacillus subtilis may be boiled for hours without destruction.

FERMENTATION, PUTREFACTION AND DECAY.

The most important and interesting faculty of the microbes is that they alter the chemical constitution of the matter in which they grow. This activity consists in breaking down the animal and vegetable substances on which they feed and reducing them once more to the simple constituents from which they were built up, as ammonia, water, carbon dioxide, etc. By *that means* and the universal occurrence of microbes in num-

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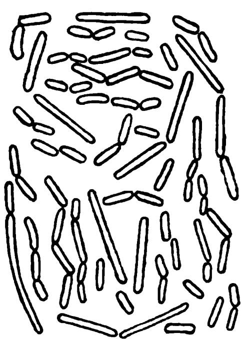
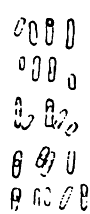
bers that may be called infinite, the dead bodies of plants and animals are split up once more into those simpler substances which serve to produce and sustain new life. Microbes have with much propriety (Sykes' Principles and Practice of Brewing) been called nature's scavengers, and without their action organic life on earth would ages ago have become impossible owing to the accumulation of dead organic matter in which the elements of life were tied up. The processes by which this work of decomposition is carried on are called *fermentation, putrefaction and decay.*

Putrefaction is the decomposition of albuminous matters, accompanied by the generation of foul-smelling gases, as sulphuretted hydrogen, ammonia, etc. This decomposition is of very common occurrence and is often brought to the notice of everybody in everyday life, f. i., in the case of rotten eggs or high meat, etc. It is the product chiefly of a numerous group of bacteria called *termobacteria.*

Fermentation is the decomposition of carbohydrates, generally sugar, by microbes, accompanied by the generation of gases not malodorous, like carbonic acid. The decomposition may be brought about by yeasts or bacteria. In the former case the products of fermentation are carbonic acid and alcohol. If due to bacteria the products of decomposition are carbonic acid and generally



Clostridium butyricum (Prazmowski) 500:1.



Bacillus viscosus (Lindner).

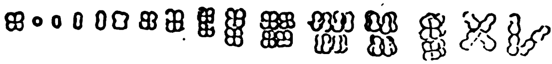
another acid like lactic, butyric or acetic, according to the kind of bacteria involved.

Decay is the slow process by which dry or moist organic sub-

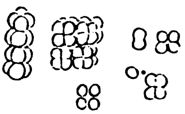
stances are gradually consumed by mold growing or feeding on them.

BIOLOGICAL DESCRIPTION.

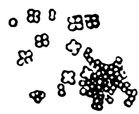
This description will be confined to such types as possess practical interest for the brewer. Only the most important characteristic marks will be given.



Pediococcus cerevisiae (Lindner).

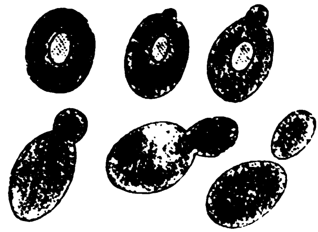


Sarcina (Lindner).



Pediococcus acidi lactis (Lindner).

Yeast spores (Hansen) 1000:1.



Budding Yeast (Sykes).

FILAMENTOUS OR MOLD FUNGI.—HYPHOMYCETES.

Molds are very common, and often infest breweries.

As a rule they require plenty of air and moisture. They occur most frequently on malting floors, starting on crushed or broken corns, on damp wood or masonry, badly cleaned vessels and implements. The danger from molds in the brewery is of a twofold nature. First, they infest the air, and, by the decomposition they perform, generating a foul odor, they impair the taste of the beer, giving it the well-known cellar taste. Secondly, the felt-like mass of mold is apt to take up spores of wild yeasts and bacteria which will grow and develop therein.

The soft, silky coating of different colors, often found on moist organic bodies, as wood, bread, fruit, barley, malt, etc., popularly called mold, is found, upon microscopical examination, to consist of a vast number of minute plants. Each plant consists of one or

TABLE I—MOLDS.

Name.	On Solid Nutritive Substrata.	Fruit and Spores.	In the Brewery.	Remarks.
Penicillium glaucum.[4] Brushmold	First white, later grayish green.	Brush-shaped fruit. The round spores are cut off by constriction at the ends of the fruit-bearing hypha, which is divided into several parts.	All over, especially in damp places, on broken barley corns and generally on the malting floor.	Occasional variation in reproduction: Two cells twisted together develop mycelium, inclosing swollen cells with 8 spores each. Generates invertin.
Mucor mucedo.[5] Headmold.	Whitish gray fluffy coating.	Branched mycelium, undivided, only one fruit on each long fruit-bearing hypha. Spores oval, inclosed in spherical heads.	Very common in the brewery.[1]	Another form of reproduction: Two hyphæ grow to meet each other, dissolve into one and form single cell (zygospore), which germinates after some time.
Oidium lactis.[6]	White, dry film.	No fruit formation. Spores are elongated and angular and are formed by the hyphæ falling to pieces.	Occurs on malt, walls of vessels, conduits and yeast. Generates small amounts of alcohol.	Found most frequently on milk.
Dematium pullulans.[7]	Whitish gray and slimy, later black.	No fruit formation. The permanent cells are big, irregular, grayish green.	Causes ropiness in beer. Develops in wort yeast-like cells reproduced by budding.	
Fusarium hordei.	Reddish.	Spindle-shaped spores.	On germinating barley.	
Eurotium aspergillus glaucus.[8] Clubmold.	Bluish-green or yellowish green.	Long fruit-bearing hyphæ, seldom branched, expanding at upper end into pear-shaped head, and having little protuberances all over, from which the knob-shaped spores separate by constriction.	On green malt.	Possesses a diastasic ferment capable of converting starch into dextrin and maltose.[2]
Monilia candida.[9]	White film.	No fruit. Long hyphæ which cut off by constriction oval or elliptical cells.	May occur in yeast.	Ferments cane sugar and maltose although possessing no invertin.[3] Generates 5 per cent alcohol in six months. Induces active fermentation at temperatures as high as 106 F

[1] Another species, mucor racemosus, when introduced into wort, produces yeast-like cells, which are reproduced by budding, and are capable of causing alcoholic fermentation. [2] Another species, aspergillus oryzæ, serves for producing the Japanese beverage called Sake. [3] Fischer doubts this.

[4] Illustration, pages 500, 501. [5] Illus., p. 499. [6] Illus., p. 503. [7] Illus., p. 501. [8] Illus., p. 502. [9] Illus., p. 504.

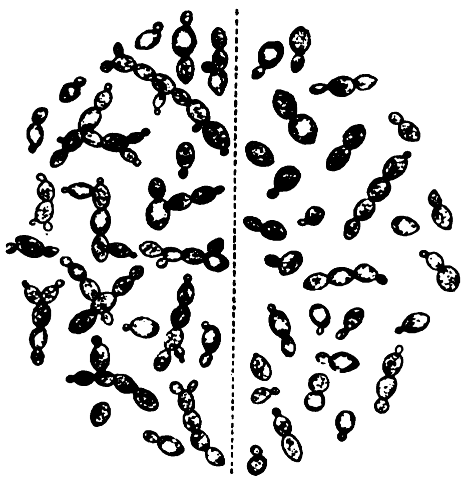
more cells, though often branching out into several threadlike tubes.

The mold fungi possess long, delicate, silky threads, or filaments (hyphæ), which develop very fast and abundantly. They penetrate organic matter, both dead and living, and, ramifying and interlacing with each other, form what is called the "mycelium," which is characteristic of these types of fungi, both in form and color.

REPRODUCTION.

From the mycelium there shoot up the aerial hyphæ, upright threads, whose function it is to bear the organ of fructification.

The common form of reproduction is by *sporulation*. Upon the upright threads are formed "spores," which occupy a place similar to that of the seeds of the higher plants, and are properly little cells within, or protruding from, the parent cell. The spores may, for instance, be inclosed in a knob called the "sporangium"



Budding Yeast (Thausing) 500:1.

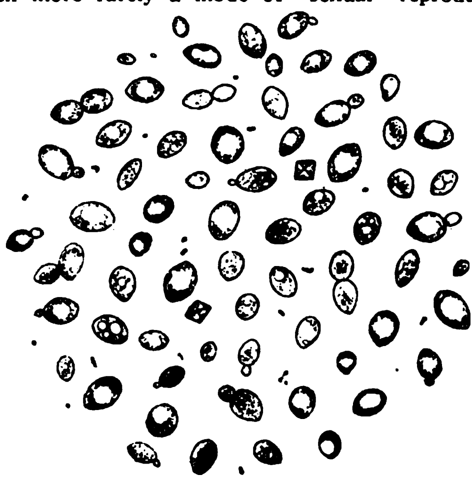
(*mucor*), or cut off by abstriction at the extremities of the upright thread which spreads out in branches (*penicillium*), or the spores may be formed by the filaments of the mycelium falling to pieces (*oidium*), etc.

[redacted]

Spores are produced without number. They are very resistant and are carried everywhere in the air. They can lie dry for years without losing their vitality, but begin to grow as soon as they find a favorable medium to live on.

As a rule, the spore, when it finds suitable conditions, develops a new mycelium, possessing the same properties as the parent plant. It is only in exceptional cases and under peculiar conditions that the spore will multiply by "budding," which is the characteristic mode of reproduction of the yeasts.

Besides this "vegetative" or "asexual" reproduction there occurs much more rarely a mode of "sexual" reproduction. A



Yeast cells resting (Thausing) 500:1.

couple of upright threads grow together (copulation) and become fused into a single cell, a kind of fruit body, called "zygospore," from which the mycelium grows at a later period, after the zygospore has dropped from the parent threads.

FISSION FUNGI OR BACTERIA.—SCHIZOMYCETES.

Bacteria are the smallest of all known living things. They are unicellular, or composed each of a single cell, consisting of protoplasm and cell wall. No cell nucleus has yet been found in any of them.

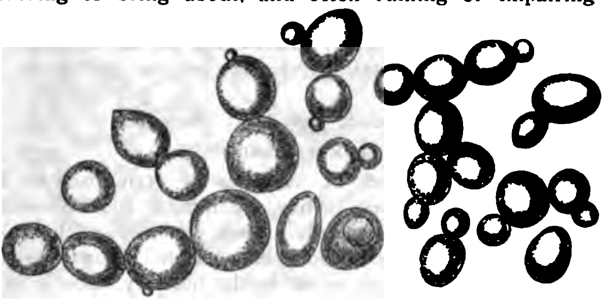
Three forms of bacteria are distinguished:

TABLE II—BACTERIA.

	Name.	Form.	Motion.	Spores.	Temperatures.	In the Brewery.	Remarks.
Putrefaction Bacteria	Bacillus subtilis (hay bacillus).	Rather long rods, often in chains or threads	Lively.	Yes.		Does not develop in liquids that contain free acid, hence not in beer wort.	Spores very hardy. Can be boiled for hours without being killed.
	Termo-bacteria.	Short rods, tight constriction in middle. No chains.	Exceedingly lively.	In some types.		Develops very fast in wort (celery odor). Is killed by the addition of an energetic yeast.	Several types are known and some of them occur in the brewery.
Fermentation Bacteria.	Butyric acid bacteria.	Rods fairly long to long.	Slow.	In some types.		Causes beer turbidity, disagreeable odor and taste.	Several types. Develops principally in the absence of air.
	Lactic acid bacteria (general form).	Rods short and thick, often 2—3 together.	None.	In some types.		Causes beer turbidity and sour taste. Particularly common in top-ferm. beers.	Several types.
	Saccharo-bacillus Pastorianus.	Rods long and thin.	None.		Killed by being heated to 122-140° F. for 10 min.	Causes the beer to "turn" or "kick up."	Generates lactic acid. Capable of fermenting various sugars.
	Acetic acid bacteria.	Rods short, thick, slightly constricted in middle, often irreg. swollen. Long chains.	None.	None.	Optimum 81° F., produces no acetic acid below 50° F., does not develop under 40° F.	Demands plenty of air and high temperatures, hence is not dangerous in well filled bottles or cold storage cellars.	Forms a slimy film on wort or beer in 2-8 days. Three types are known. In the brewery bacterium aceti is the most frequent.
	Bacillus viscosus I and II.	Short rods.	None.	Yes.	For inducing viscidity: Minimum 45° F.; optimum 92° F.; maximum 108° F.	After 24 hours wort is viscous, after 48 hours as coherent as white of egg, CO_2 being produced. No development upon inoculation after main fermentation.	
Pigment Bacteria.	Sarcina.	Spherical coccus, 2, 4, 8 joined. 1. Pediococcus, grow by division in two planes. 2. Sarcina proper, grow by division in three planes.	Trembling. (no flagella).	No.	Is destroyed at 140° F.	Very widespread, especially in bottom-fermentation beers. Develops faster in dark beers. May cause turbidity and bad taste.	Increased amounts of hops will impede their development. Small quantities of various acids destroy them.

1. Spherical (*coccus*).
2. Rod-shaped (*bacillus*).
3. Spiral-shaped (*spirillum*).

Owing to their universal presence bacteria will also enter the brewery and are apt to interfere with the work there going on, modifying the different processes which the brewer is endeavoring to bring about, and often ruining or impairing the



Saccharomyces cerevisiae (Hansen) 1000:1.

result of his efforts, unless proper precautions are taken. Hence the importance of being acquainted with the bacteria.

REPRODUCTION.

Under favorable conditions all bacteria reproduce themselves by "fission," or splitting. An elongation takes place and a partition grows across the width of the body, at which point the original cell splits into two parts which either separate or hang together in chains.

The spherical bacteria are the only ones capable of splitting up in more than one direction, a spherule sometimes dividing in two or three directions.

A considerable number of bacteria will, under certain conditions, form spores. Such spores are round or oval bodies of great refractive power and consequently present a glistening appearance under the microscope. They are invariably grown within the cell body (endogenous), and occur more frequently among the bacilli, more rarely among the cocci.

Irregular forms are sometimes found in older cultures. They are caused by degeneration of the bacterium cells and are called "involution forms."

Some bacteria are characterized by the power of locomotion,

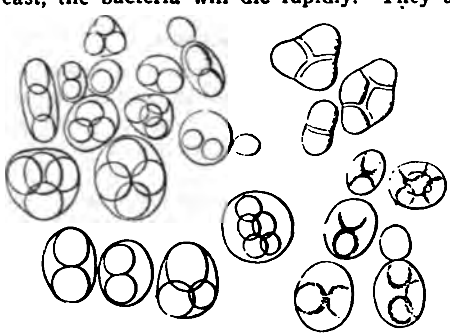
which is brought about by special whip-like organs called "flagella." These slender threads become visible under the microscope only by staining.

Of bacteria the number in nature is without end. A great many of them have been examined and described, but those which are met with in brewing operations are few. Passing by the methodical classification of bacteria in general, those which concern the brewer may be reduced to three classes:

1. Bacteria of putrefaction: Termobacteria, hay bacillus.
2. Bacteria of fermentation: Lactic, butyric and acetic acid bacteria.
3. Bacteria which produce pigments: Sarcina.

TERMOBACTERIA.

A considerable number of varieties of termobacteria have been found and described. They are minute rods, showing a tight constriction in the middle. They never form chains, but are exceedingly motile. Some have been shown to raise spores. But few of them occur in the brewery, mostly in the wort, which in that case sends up a peculiar odor as of celery. If a wort that is infected with termobacteria is pitched with a vigorous yeast, the bacteria will die rapidly. They are seldom



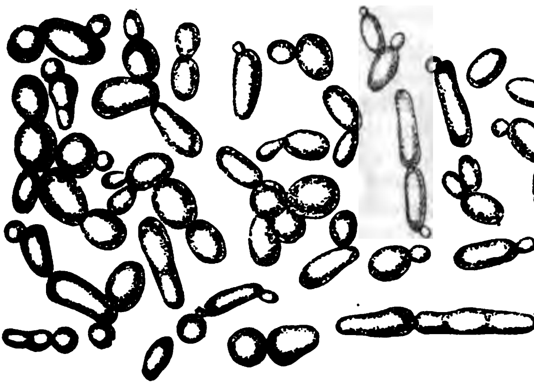
Saccharomyces cerevisiae with ascospores (Hansen) 1000 : 1.

found in the finished beer. On the other hand, they develop readily and quickly in yeast while in a resting condition. (See illustration, page 505.)

HAY BACILLUS.

The hay bacillus (bacillus subtilis), which is remarkable for *the extraordinary* resistance of its spores, is another bacterium

of putrefaction. It was formerly asserted that this bacillus was met with in wort and beer. It has been shown by recent experiments that it is incapable of development in hopped wort, particularly in the presence of appreciable amounts of free acid.



Saccharomyces pastorianus I (Hansen) 1000:1.

BACTERIA OF FERMENTATION.

The following fermentations are caused by bacteria:

1. Lactic acid fermentation.
2. Butyric acid fermentation.
3. Acetic acid fermentation.
4. Viscous fermentation (of beer).

LACTIC ACID BACTERIA.

The bacteria by whose activity milk is soured consist of short, thick, plump rods, which are often joined in groups of two or three and possess no means of locomotion. Many of them have been isolated, some reproduce themselves by means of sporulation, and some without. Several varieties are met with in brewing operations, principally in top-fermentation breweries, the sour taste of their product depending mainly upon these bacteria. (For certain pediococcus types that are active in producing this result see "Sarcina.") In bottom-fermentation beers they are able to produce turbidity and a sour taste.

Besides these, the more common lactic bacteria, another bacterium of this class is *saccharobacillus pastorianus*. This *organism is able* to grow both in wort and beer. It also ger

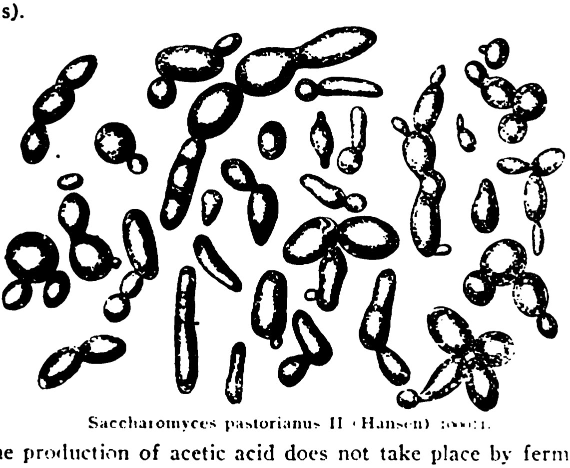
crates lactic acid. It is not motile. It is responsible for the turning of beer, and is capable of fermenting such sugars as maltose, saccharose, and dextrose. No spores have yet been found in this bacillus. (See illustration, page 505.)

BUTYRIC ACID BACTERIA.

These also are of many varieties. Often they are fairly long rods, although shorter forms are also met with. They move slowly, and some of them at times reproduce themselves by spores. With few exceptions they are "anaërobic," i. e., they develop more rapidly, and in some cases exclusively, in the absence of air. Those types which occur in brewing operations are liable to impart a disagreeable taste, rancid odor, and haziness to the beer. They are very sensitive to the bactericidal action of hops. (See illustration, page 505.)

ACETIC ACID BACTERIA.

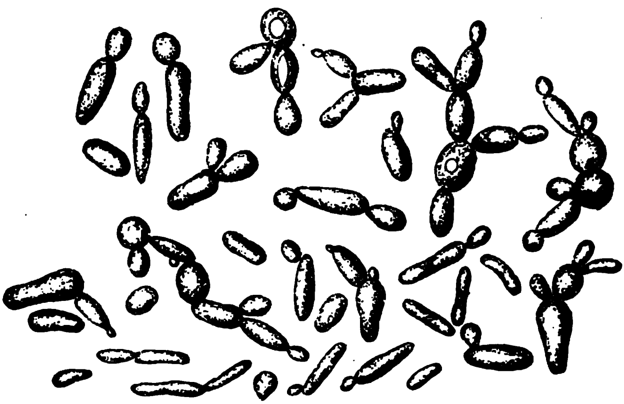
Of the four varieties known but one has been found in breweries, viz., *bacterium aceti.* They are short rods, slightly constricted in the middle, and often forming long chains. In old cultures long, irregularly swollen forms are seen (involution forms).



Saccharomyces pastorianus II (Hansen) [illegible]

The production of acetic acid does not take place by fermentation, properly speaking, but by the oxidation of alcohol. The *best temperature is* 80° F. No acetic acid is formed below *50° F., and the acetic* bacteria do not develop at all at temperatures *under 41° F.* (See illustration, page 506.)

The acetic bacteria require an abundant supply of air. At higher temperatures they form a viscous film or pellicle on the surface of beer—mother of vinegar—within a few days, which is always a ready means of identification. They give to beer



Saccharomyces pastorianus III (Hansen) 1000:1.

a vinegar-like odor, and are more resistant to the antiseptic action of the hops than the lactic bacteria. When treated with iodine solution the jelly-like mass by which they are enveloped is stained yellow.

The most common varieties outside of the brewery are *bacterium pasteurianum* and *bacterium Kuetzingianum*. They differ from bacterium aceti in the circumstance that iodine solution will give a blue color to them, or rather to the viscous substance enveloping them, while the iodine itself does not take any different color. The acetic bacteria possess no motion and do not form spores. (See illustration, page 506.)

BACTERIA OF VISCOUS FERMENTATION.

The organisms of this species are rather short, slender rods. Two varieties have been described, viz., *bacillus viscosus I* and *II*, both having been found in beer. They are not motile, and the spores are produced at the ends. In 24 hours after infection these bacilli induce viscidity ("ropiness") in beer, and in 48 hours the wort is converted into a mass as coherent as white of egg. *The viscous condition* is produced most rapidly at 91° F.;

[redacted]

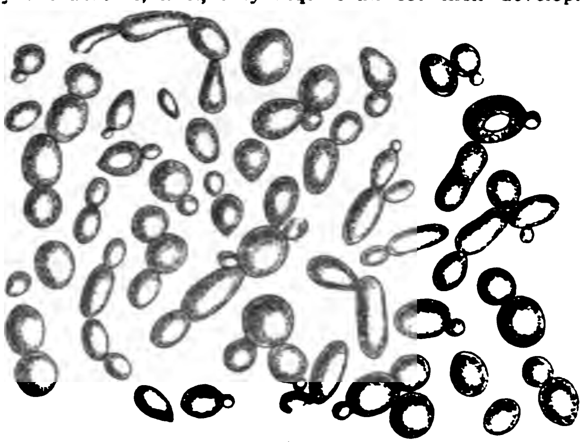
the action ceases above 107° F. and below 44° F. No action is observed if the infection of the beer occurs after the principal fermentation. The viscous bacteria appear more particularly in top-fermentation beers. (See illustration, page 507.)

SARCINA.

The most common bacteria in bottom-fermentation breweries are sarcinæ. They consist of minute spherules, almost invariably 2, 4, 8 or more clinging together in a packet. They may be divided into two groups, *pediococcus* and *sarcina* proper.

The former grow in one plane, that is, in two directions, the latter in all three directions. The former appear colorless on gelatin, the latter give a variety of colors. All of them produce acid, chiefly lactic, in varying quantities.

While they may be found in almost every bottom-fermentation yeast, they induce comparatively rare diseases in beer. Some beers, especially dark ones, are more subject to sarcina disease. Under certain conditions, not yet fully understood, and in certain years, or at certain seasons, they appear almost epidemically. They are aërobic, i. e., they require air for their development,



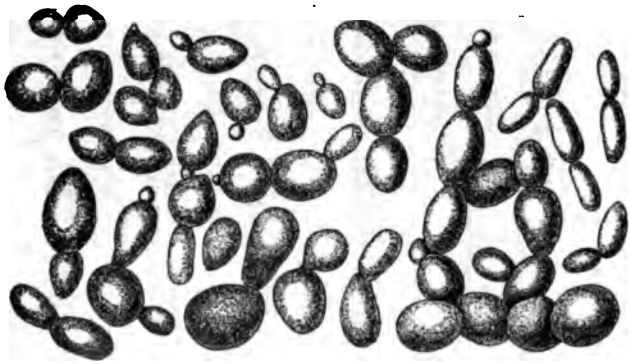
Saccharomyces ellipsoideus I (Hansen) 1000:1.

but only in small quantities. Liberal additions of hops and *certain acids* will inhibit their growth and multiplication.

Sarcina does not form spores and possesses a trembling motion. No flagella have been found on them. (See illustration, *page 508.)*

BUDDING FUNGI, OR YEASTS.—BLASTOMYCETES.

The soft, mushy mass, known to the brewer as *yeast*, consists of countless cells of round or oval shape, either lying single or joined into groups. Their length varies from 3 to 10 micromillimeters. Each of these cells is an individual yeast plant of the unicellular kind, belonging to the class of the "budding" fungi



Saccharomyces ellipsoideus II (Hansen) 1000:1.

(blastomycetes) and like those of the molds, consists of protoplasm, enveloped in a cell-wall of cellulose. The uneven distribution of the contents of the cell causes the appearance of specks, like little bubbles, which are called "vacuoles." Some yeast types have been definitely shown to contain a "nucleus" in the cell. It appears like a small, round body, and seems to be controlling the activities of the cell in a way as yet not fully explained.

The protoplasm which fills the cells varies in appearance with the age and vigor of the plant. In young, strong cells it is foamy, almost transparent, becoming more granular as the yeast grows older. The nucleus is ordinarily invisible. Weak cells contain more vacuoles than strong ones.

Living protoplasm does not take up a staining agent, such as indigo or methylene blue solution, whereas dead protoplasm attracts many dyes. If yeast is mixed with a drop of a dilute staining fluid, like methylene blue, the dead yeast cells can be readily detected by the blue color they assume.

TABLE III. YEAST FUNGI.

Name.	Type.	Form of young sediment yeast.	Temperature and time of sporulation. Maximum.	Minimum.	Optimum.	Optimum of film formation.	Ferments Maltose.	Dextrose.	Sacharose.	Invertin.	Remarks.
Saccharomyces cerevisiæ (Culture yeast).	Top fermenting.	Cells large, mostly spherical.					Yes	Yes	Yes	Yes	
	Bottom fermenting.	Cells generally oval, often somewhat elongated.					Yes	Yes	Yes	Yes	
Saccharomyces Pastorianus I.	Bottom fermenting.	Cells for the most part much elongated, sausage shaped, at times smaller, round or oval.	85-87 °F 30 hours.	37-39 °F 14 days.	81.5 °F 24 hours	79-82 °F 7-10 days.	Yes	Yes	Yes	Yes	Occurs frequently in the brewery. May cause an unpleasant, *bitter* taste, also turbidity, in beer.
Saccharomyces Pastorianus II.	Weakly top fermenting.	Cells for the most part much elongated, sausage shaped, at times smaller, round or oval.	81-82 °F 34 hours.	37-39 °F 17 days.	77 °F 25 hours.	79-82 °F 7-10 days.	Yes	Yes	Yes	Yes	Causes no beer diseases.
Saccharomyces Pastorianus III.	Top fermenting.	Cells for the most part much elongated, sausage-shaped, at times smaller, round or oval.	81-82 °F 35 hours.	47 °F 9 days.	77 °F 28 hours.	79-82 °F 7-10 days	Yes	Yes	Yes	Yes	May cause beer turbidity.
Saccharomyces ellipsoideus I.	Bottom fermenting.	Cells mostly oval or round somewhat smaller seldom sausage-shaped	87-89 °F 36 hours.	45.5 °F 11 days.	77 °F 21 hours.	91-93 °F 8-12 days.	Yes	Yes	Yes	Yes	This is the wine yeast. Found on ripe grapes.

TABLE III. YEAST FUNGI.—Continued.

Name.	Type.	Form of young sediment yeast.	Temperature and time of sporulation.			Optimum of film formation.	Ferments				Remarks.
			Maximum.	Minimum.	Optimum.		Maltose.	Dextrose.	Saccharose.	Invertin.	
Saccharomyces ellipsoideus II.	Tending toward bottom fermenting.	Cells mostly oval or round, somewhat smaller, seldom sausage-shaped.	91-93 °F 31 hours.	46 °F 9 days.	84 °F 22 hours.	91-93 °F 3-4 days.	Yes	Yes	Yes	Yes	May cause beer turbidity.
Saccharomyces apiculatus.	Bottom fermenting.	Cells lemon-shaped, pointed or oval.					No	Yes	No	No	Is not a saccharomyces, since it does not form spores. Found on ripe fruit, almost always in wine yeast, often in the Belgian beers with spontaneous fermentation.
Mycoderma cerevisiæ.	Several types.	Cells of some types, oval, generally elongated, sausage-shaped				77 °F 2-3 days.					Many types may cause turbidity and bad taste in beer. Older cells generally contain 2-3 globules of fat.
Torula.	Several types.	Cells of some types oval, generally round and small.									Only few types are capable of causing fermentation. Cause no beer diseases. Some types produce a red pigment (pink yeast.)

TABLE IV. CULTIVATED YEASTS

Name.	Type.	Apparent Attenuation.	Time of Fermentation.	Character of the Beer.	Remarks.	Used in
Carlsberg 1.	Bottom.	Higher than Carlsberg 2	——	Beer more stable than 2. For lager and export beers.	Low foam, poor cover, clarifies slowly. Fluid sediment of yeast.	Denmark.
Carlsberg 2.	Bottom.	Fermentation more feeble than Carlsberg 1.	——	Taste of beer finer than 1. For keg (city) beer.	Thick high foam, dense cover, clarifies comparatively quick. Firm sediment of yeast.	Denmark.
Frohberg.	Bottom.	75%	11 days.	Beer more stable than Saaz. For lager and export beers.	Slowly settling.	Germany and United States.
Saaz.	Bottom.	62%	11 days.	For city beers.	Quickly settling.	
Chicago 1.	Bottom.	70%	9-12 days.	Beer more stable than Chicago 2. For export beers.	Yeast does not settle so quickly as Chicago 2.	United States.
Chicago 2.	Bottom.	65%	11-14 days.	For city beers.	Yeast settles quickly and beer clarifies quicker than Chicago 1.	United States.
Logos.	Bottom.	94%	15 days.			Brazil.

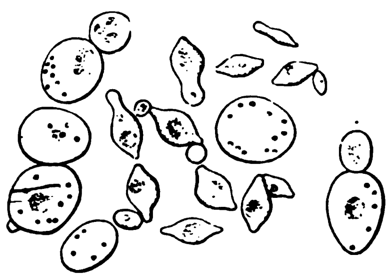
REPRODUCTION.

Reproduction proceeds by "budding." At some point in the cell-wall a protuberance rises, which speedily grows to nearly the size and shape of the parent cell. A partition forms between the bud and the parent cell. The new cell is not always detached from the old one at once, but many cells sometimes remain clinging together for a time, forming clusters.

The budding fungi do not exhibit that completely systematic form of growth seen in the molds, finishing with the fruit. Under normal conditions, i. e., such as are favorable for their growth, these organisms multiply by continued budding. Under certain conditions, however, some varieties will develop spores, which constitute the resting form of the yeast cells.

Many scientists, among whom Brefeld was first, have sought to show that the yeast fungi are not an independent species, but merely developmental forms of the molds. The principal point of similarity is that some molds are capable of reproduction by budding.

Emil Chr. Hansen showed repeatedly that the yeasts are a species by itself, and it was chiefly by utilizing sporulation as a



Saccharomyces apiculatus (Hansen) 1000:1.
The larger cells are sacch. cerevisiae.

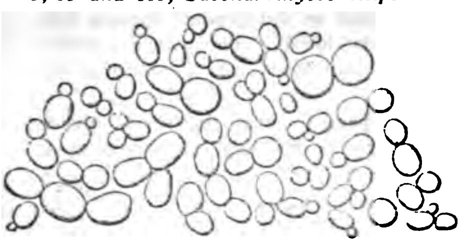
feature of distinction that he succeeded in establishing different types of yeast. In this respect the most important elements to be considered are the limits of temperature and time in which spores are produced.

Some types of yeast have been observed to produce a mycelium, slender, oblong cells being formed, which, however, do not *interlace.*

A genuine mycelium is found only in isolated types and, like the films (or spurious mycelia) which occur with most yeasts under certain conditions, is of great diagnostic importance.

CLASSIFICATION.

All those yeasts which produce spores belong to the species *saccharomyces*, which includes the two large divisions of yeasts called cultivated (culture) or beer yeasts, and wild yeasts, the latter division comprising all those yeasts which form spores, but are not cultivated. These are found in nature generally in great abundance on the skins of ripe fruits, are carried by the air from place to place, and thus find their way into the brewery where they are unwelcome guests under circumstances giving rise to beer diseases. Among these are *Saccharomyces Pastorianus I, II and III, Saccharomyces ellipsoideus I and II.* By an in-



Torula No. 7 (Hansen) 1000:1.

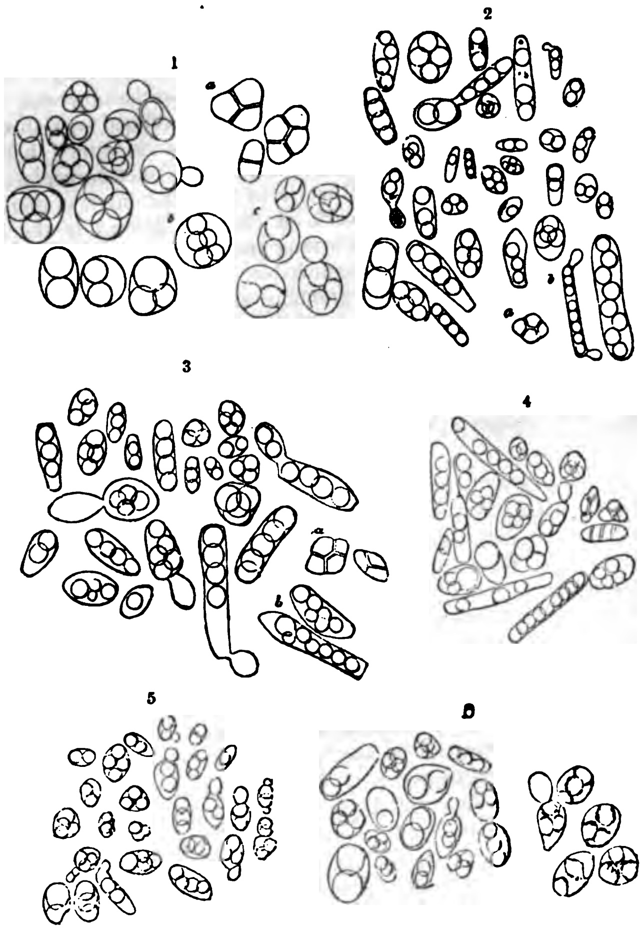
Torula No. 6 (Hansen) 1000:1

accuracy the yeast called "apiculatus" bears the name of "saccharomyces." It does not form spores, but becomes interesting on account of a detailed and instructive description of its life by Hansen. (See illustration, pastorianus 515, 516, 517; ellipsoideus 518, 519; apiculatus 523.)

Those yeasts which do not form spores are divided into *mycoderma*, which with great rapidity form a characteristic film on wort or beer, and *torula*, consisting of minute, mostly spherical yeast cells, which, however, do not induce any beer diseases.

SPORULATION.

The most important mark of distinction of cultivated yeast from wild yeast is sporulation, which affords the only decisive test whether a yeast is a culture yeast or not. A fresh, young culture of a culture yeast on a gypsum block at 77° F. will form spores much more slowly than the other saccharomycetes, or



Yeasts with spores (Hansen) 800:1.

1. Sacch. cerevisiae.
2. Sacch. pastorianus I.
3. Sacch. pastorianus II.
4. Sacch. pastorianus III.
5. Sacch. ellipsoideus I.
6. Sacch. ellipsoideus II.

wild yeasts. As a rule, sporulation will not begin for three or four days, whereas the wild yeasts will evince a manifest disposition for sporulation within 40 hours at the same temperature. Only in a few cases a temperature of 59° F. is preferable, in which case sporulation will take a correspondingly longer time.

Under certain conditions most of the saccharomycetes can be made to produce films. But the film develops very slowly, and often only in patches or detached pieces, which hardly cover the surface. (An exception is *sacch. membranaefaciens* and some others.) This feature is of scientific interest merely.

Another distinguishing mark of the two groups is the appearance of the spores. The young spore of the cultivated yeast has a cell-wall plainly distinguishable, and the contents of the spore are not uniform but granular and dotted with vacuoles. The wild-yeast spore, on the other hand, most frequently shows an indistinct cell-wall, and its contents are more refractive and uniform.

(See also "Yeast and Fermentation," "Pure Yeast Culture" and "The Brewer's Microscopical Laboratory.")

YEASTS AND FERMENTATION.

HISTORICAL AND EXPLANATORY.

It is beyond the scope of this book to treat the development of the science of fermentation elaborately, but it may be desirable to review quite briefly the history of the theory of fermentation.

At different periods the theories of Liebig, Pasteur, Traube, Naegeli and Buchner have served successively to explain the various phenomena attending the process of alcoholic fermentation.

The process of fermentation was undoubtedly practiced in prehistoric times. It was not, however, until the middle of the eighteenth century that science had advanced sufficiently to recognize the gas escaping from fermentation as identical with that produced by the combustion of charcoal, which is now known as carbonic acid gas. Lavoisier, in 1789, was the first to recognize that fermentation was essentially a process of splitting up sugar into two portions, viz., alcohol and carbonic acid, in about equal quantities, "which, if it was possible to reunite, ought to form sugar," while it remained for Pasteur to show that glycerin and succinic acid were regular products of fermentation.

Appert, in the beginning of the nineteenth century, was the first to produce evidence that yeast was necessary for the fermentation of sugar. He preserved beer wort unfermented by simply excluding air from contact with boiled and cooled wort, whereas, if yeast was introduced in such cooled wort fermentation soon set in, though air was excluded. Appert founded a method of preserving perishable articles of food on the principle of heating and excluding air, and thus became the originator of what is now generally termed the process of pasteurization.

The true nature of yeast was not scientifically demonstrated, however, until Cagniard de la Tour and simultaneously Schwann in 1838 described yeast as consisting of numberless living organisms, which multiplied rapidly by budding, and the presence of which in a solution of sugar was absolutely necessary to cause fermentation.

Stahl was the first to formulate a theory which was afterward adopted by Lavoisier for the breaking up of sugar. Long before the nature of yeast was known he advanced the proposition that the ferment communicated its own internal motion to the sugar with the effect of reducing it to new substances. "As chemistry advanced," says Huxley, "facts came to light which put a new phase upon Stahl's hypothesis and gave it a safer foundation than it previously possessed. The general nature of these phenomena may be thus stated: A body A, without giving to, or taking from, another body B, any material particles, causes B to decompose into other substances, C, D, E, the sum of the weights of which is equal to the weight of B, which decomposes."

Some time after Stahl, Thénard, in 1803, explained the decomposition of the sugar by assuming that the ferment combines with a portion of the oxygen of the sugar, thus causing the fermentation to commence; the equilibrium between the principles of the sugar being disturbed, carbonic acid and alcohol is formed. Thus Stahl becomes the forerunner of Liebig, and Thénard of Pasteur.

Schwann undertook his experiments mainly with a view of refuting the doctrine of spontaneous generation, which assumed that living organisms could develop out of lifeless matter without the agency of eggs, germs, seeds, etc. He disposed of that doctrine effectually by showing that air might be admitted in any quantity to solutions which had been boiled in flasks without causing fermentation or putrefaction, provided the germs contained in such air were destroyed.

Liebig was of opinion that fermentation was not dependent upon the vital activity of the yeast plant, that the splitting up of sugar into alcohol and carbonic acid takes place under certain circumstances without growth, development or reproduction of yeast, and that this process is brought about through peculiar chemical changes that take place in certain nitrogenous constituents of the yeast cell which affect the molecules of

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sugar sufficiently to bring about decomposition similarly as the inversion of cane-sugar into dextrose in contact with yeast is due to its nitrogenous constituent, invertase.

Pasteur considered the splitting up of sugar into alcohol and carbonic acid a function of the living yeast organism. Fermentation was with him the result of a physiological process, which would set in when the yeast was unable to obtain from its surroundings free oxygen necessary to the exercise of its vital activity. In this case it would extract the required oxygen from the sugar contained in the solution in which the yeast is immersed, resulting in the splitting up of the sugar molecule into alcohol and carbonic acid gas.

A. J. Brown showed that if two fermentations are conducted under the same conditions and so as to arrest entirely the growth of the yeast, the fermentative energy of the yeast in one liquid will be increased if aërated as compared with the other one which is not aërated, thus refuting Pasteur's theory.

Traube, in 1858, explains alcoholic fermentation as being brought about by the influence of ferments (enzymes) contained in the yeast cells, these ferments having a definite chemical composition and being analogous in their action to such substances as diastase, these substances having the power of transferring the oxygen from one group of atoms that constitute a chemical substance, to another group of atoms, thereby causing, as in the case of sugar, a splitting up of complex molecules into simpler ones.

Naegeli claims, unlike Pasteur, that the splitting up of sugar takes place outside and not inside the yeast organism, and is effected by vibrations emanating from the molecules composing the living protoplasm of the yeast cells. The action of the yeast would thus be a purely physical and not a chemical (Liebig), physiological (Pasteur), or enzymatic one (Traube).

Fischer showed that the action of yeasts on sugars is a purely chemical function due to enzymes that the yeast contained; that of the sugars, dextrose, levulose, galactose, are directly fermentable, while other sugars, like saccharose and maltose, are fermentable only in case the yeast contains the corresponding enzymes which, like invertase, changes saccharose to dextrose, or maltase, which changes maltose to dextrose. The power of *yeast to ferment* sugar is dependent upon the conformity of the

geometrical structure or configuration of the sugar molecules with the molecules composing the active agencies or enzymes of the yeast cell, like the construction of a key must conform to the construction of a corresponding lock. The sugars, with a larger molecular weight (saccharose, maltose), are split up or unlocked, yielding sugars with a smaller molecular weight, like dextrose, which then falls apart into alcohol and carbonic acid by the action of yeast.

Will showed that dead yeast may cause fermentation phenomena, that is, decomposition of sugar into alcohol and carbonic acid, and offered in explanation for this and the other fact that watering of yeast lowers its fermentative energy, the suggestion that an enzyme-like substance is contained in yeast which does not lose its power of splitting up sugar with the death of the yeast, and which being soluble in water is extracted from the yeast during the watering process.

It remained for Buchner to obtain a solution of this enzyme-like substance from the yeast by rupturing the yeast cell by means of grinding pressed yeast with sand and then subjecting the moistened mass to an immense pressure. After filtration, this clear liquid, when brought together with sugar solutions, induced fermentation just as the living yeast cells would have done. Buchner calls the enzyme contained in this solution from yeast, zymase.

Buchner's theory was not permitted to go entirely unchallenged. It was claimed that the action of the yeast-juice could be explained by assuming that fermentation was due to the particles of living yeast-plasma contained in the juice, and not necessarily to an enzyme-like substance.

This objection was also met by Buchner, who subjected yeast-juice to the action of a centrifugal machine. All particles in suspension, including yeast plasma, were thus collected in one part of the liquid and another part obtained free from yeast-plasma, which latter portion showed the same power of fermentation as the liquid containing the plasma.

Fermentation would thus, if Buchner's theory is correct, appear to be a process similar to the splitting up of starch *into maltose* and dextrin, which, as we know, is effected by *the enzyme diastase* contained in the malt. Fermentation, as *well as inversion*, then would be nothing more than enzymatic

action; and these two interesting phenomena would at last admit of a common explanation.

Although yeast had been observed under the microscope as early as the beginning of the eighteenth century by Lieuwenhoeck, it was not until Cagniard de la Tour, Schwann and Mitscherlich took up the subject more than a hundred years afterward, that yeast was described and its importance in fermentation recognized. Kützing, about the same time, described the acetic acid ferment, while it was left to Pasteur to discover, study and describe numerous microbes, capable of inciting fermentation, differing from one another, particularly in their products. Pasteur was thus enabled to point out the characteristics of alcoholic, butyric acid, acetic acid, lactic acid fermentations, and it was due to his investigations that the importance was brought home to the winegrower and later to the brewer of excluding from their respective fermentations those microbes, through whose agency the products of wine cellar or brewery are injured. In order to accomplish this end, it was Pasteur's aim, among other precautions, to free the yeasts from undesirable foreign organisms. Although he achieved this object, practically, as far as bacteria were concerned, his methods did not permit of a separation of a mixture of desirable and undesirable types of yeast. This it was left for the master hand of Hansen to accomplish, whose methods are treated elsewhere in detail. (See "Pure Yeast Culture.")

Hansen was thus enabled to point out that the yeasts commonly employed in the brewery, besides often containing wild yeasts, were commonly mixtures of different species of cultivated yeast, each of which, when isolated and used as a pure culture, would give a beer with peculiar properties; that some species of culture yeast found in such mixtures could, under certain circumstances, produce beer diseases. Thus a judicious selection of the type of yeast to be employed becomes an all-important factor in brewing. Hansen's methods and results have been of inestimable value, both for the advancement of purely scientific methods of research and from an economical standpoint.

FERMENTATION OTHER THAN ALCOHOLIC.

Besides alcoholic fermentation there are observable, wherever *microbe life finds* proper conditions for its sustenance, other

phenomena like souring, decay, putrefaction, all of which are due to the action of these microbes.

When the substances decomposed in this way are of vegetable origin, like maltose, etc., we call the process fermentation. Thus we speak of alcoholic fermentation, lactic acid fermentation, butyric acid fermentation, acetic acid fermentation. When the substances decomposed in this way are of animal origin, like the albumen of meat, we call the process putrefaction. This distinction cannot, however, be strictly maintained, since vegetable matter, like vegetable albuminoids, can give rise to putrefaction also. We then may properly speak of rotten fermentation. (See Micro-organisms.)

The term "putrefaction," therefore, is generally applied to the decomposition of substances, whether of vegetable or animal origin, by microbes if it is accompanied by the generation of foul gases, like a mixture of ammonia, sulphuretted hydrogen and carbonic acid. The term "fermentation" is used when such decomposition by microbes is accompanied by the generation of alcohol or acids, like lactic acid, butyric acid, acetic acid, besides carbonic acid.

Each species of microbe may be considered to generate its own typical fermentation product. Alcohols are produced by the alcoholic ferment, yeast; lactic acid, by the lactic acid bacteria; butyric acid, by the butyric acid bacteria; acetic acid, by the acetic acid ferments; while some kinds of bacteria, like "bacterium termo," generate in beer wort foul smelling gases.

It should be the brewer's most earnest endeavor to keep wort, beer and yeast free from such microbes as produce undesirable fermentations like butyric acid ferment, acetic acid ferment, sarcina.

Besides, these foreign organisms, being much smaller than yeast, cannot be so readily removed from the beer as yeast-cells, thus giving rise to turbidities and impairing the durability of beer.

Bacteria may be called, with Tyndall, "the weeds of the microscopic garden, which often overshadow and choke the culture plants." The brewer's aim should be to paralyze, if he cannot *annihilate*, the bacteria.

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ALCOHOLIC FERMENTATION.

Alcoholic fermentation, then, is the process of splitting up sugar into alcohol and carbonic acid, in equal parts, approximately, through the action of the alcoholic ferment, yeast. Glycerin and succinic acid are produced in small quantities by the same process.

The industries which are based upon alcoholic fermentation are:

Wine Production, utilizing chiefly the wild yeast called "saccharomyces ellipsoideus."

Distilling of Spirits, utilizing the culture yeast of beer, "saccharomyces cerevisiæ."

Pressed Yeast Manufacture, utilizing distillers' yeast.

Brewing. For lager beer, culture yeast of beer, "saccharomyses cerevisiæ," is used. The same organism is also used for the production of ale, stout, porter and weissbier, but wild yeasts are left to take care of the secondary fermentation in stock beers of top-fermenting type. Lambic and Faro are fermented by wild yeasts and bacteria in both principal and secondary fermentations.

BEER YEAST.

The most remarkable faculty of the yeast plant, from the practical point of view, is its power of exciting alcoholic fermentation, i. e., of splitting up sugar into alcohol, carbonic acid and some other bodies.

Cultivated (culture) or Beer (brewers') Yeast (*saccharomyces cerevisiae*) is divided into two great groups: *Top-fermentation* and *bottom-fermentation yeasts.* They are two distinct species, since, after many experiments, it has been found impossible by any process of treatment to convert one type into the other. Top-fermentation yeasts have the faculty of forming spores more speedily and readily than bottom-fermentation yeasts.

Each of these groups or species embraces many varieties or types, which differ in a number of important marks, as:

1. The degree of attenuation to which they can carry a wort, i. e., that portion out of 100 parts of extract in wort which is fermented by them. Accordingly they fall into "high attenuating" and "low attenuating" yeasts.

2. The time of fermentation, i. e., "fast attenuating" and "slowly attenuating" yeasts.

3. Reproductive energy or growth of yeast.

4. The rapidity with which they settle, i. e., rapidly clarifying aud slowly clarifying yeasts.

5. The stability of the beer produced by their aid.

6. The taste they give to the beer.

7. The size and shape of the cells, round or oval, etc.

ORGANIC CHANGES IN YEASTS.

Probably the culture yeasts have been derived from the wild yeasts, through a very slow process of variation through the influences of environment. To what extent such changes still go on or may be brought about artificially remains an open question. Hansen developed Carlsberg Bottom Yeast No. 1 for some time in unaërated wort, and found that the cells displayed an abnormal behavior, when again brought into wort under normal conditions, while Carlsberg Bottom Yeast No. 2, although it also was influenced in the same manner, regained its normal functions quickly. Again, from one cell of *Saccharomyces Ludwigii* were obtained by culture under different conditions three different varieties, of which one would easily develop spores, another with difficulty and the third not at all, regaining this power, however, again in a measure after continuous cultivation of the cells in beer wort. (Centralblatt für Bacteriologie und Parasitenkunde, 1889, page 632).

Hansen also succeeded in modifying the functions of cells of *Saccharomyces Pastorianus I* to such an extent as to lose entirely the power of spore formation. (Centralblatt für Bacteriologie und Parasitenkunde, 1895, page 860). Hansen likewise brought about another highly interesting change in the modification of a high attenuating yeast, so that it gave a constant lower attenuation and better clarification of the fermented beer.

DIFFERENCES IN THE BEHAVIOR OF YEASTS.

YEASTS AND SUGARS.

Yeasts contain one or more enzymes, which bodies have the power of inverting certain kinds of sugars which are not directly fermentable, into other sugars contained in the wort. These enzymes are invertase and maltase. Only dextrose and levulose in wort are directly fermentable. Saccharose, maltose and *malto-dextrin must* first be changed into these before fermenta*tion can take place.*

Invertase is the enzyme that inverts saccharose, maltase the one that inverts maltose and malto-dextrin. Only such yeasts will ferment saccharose as contain invertase; only such will ferment maltose as contain maltase.

Hansen found that all saccharomyces varieties with the exception of *saccharomyces membranaefaciens* produce alcohol from saccharose and dextrose, that is, they all contain invertase. All culture yeasts and most of the wild yeasts can also ferment maltose. They therefore contain both invertase and maltase.

Saccharomyces exiguus ferments saccharose but not maltose, hence, contains no maltase. Mycoderma, which is not a true saccharomyces, since it forms no spores, cannot ferment sugar.

Saccharomyces apiculatus, which is also unable to form spores, and is therefore really not to be considered a true saccharomyces, can ferment dextrose, but not saccharose or maltose. It contains no sugar inverting enzyme.

Some *Torula* yeasts, which are not true saccharomyces, contain invertase, others not. None of them seem to contain maltase.

Some molds like *Monilia candida* and *Schizo-saccharomyces octosporus, Mucor circinelloides* and *Eurotium oryzae* are capable of splitting up certain sugars into alcohol and carbonic acid. Like yeasts, these molds contain the corresponding enzymes. The two last mentioned molds also contain diastatic enzymes since they also invert starch into sugar.

YEASTS AND RAFFINOSE.

Raffinose or melitriose is a sugar contained in small quantities in barley. Berthelot found in 1889 that the ordinary bottom-fermentation yeasts of the French breweries fermented it completely, whereas, top-fermenting bakers' yeast fermented only about one-third, and Loiseau found that this difference in behavior toward this sugar could be traced to all bottom and top yeasts examined by him, thus affording a basis of distinction between the two. (Zeitschr. f. d. ges. Brauwesen, 1889, p. 186.) Bau found that bottom-fermentation yeasts have the power of splitting melitriose into melibiose and levulose, after which melibiose is split up by an enzyme that Bau calls melibiase into levulose and galactose, all of which sugars are fermentable, whereas top-fermentation yeast containing no melibiase cannot ferment melibiose. (Chemiker Zeitung, 1895, page 1873).

For yeasts and the carbohydrates of the wort, see "Diastase and Starch," page 416.

CLARIFICATION.

The rapidity with which beer will clarify in fermenting vat after the principal fermentation, or in the chip-cask with the aid of isinglass, is largely dependent upon the size of the yeast cells, but also upon their power of forming a gelatinous secretion, in which the yeast cells become imbedded, forming bunches of cells that settle on the bottom more readily than single cells, giving rise to the so-called "break." This bunching tendency naturally will also affect attenuation, taste, and durability of the beer, since a yeast that will settle rapidly will leave a larger remnant of sugar in the beer than one that remains longer in suspension. The employment of quickly settling yeasts, as a general rule, will result in lower attenuated beers, shorter duration of fermentation, quicker clarification of beers, better "break," more compact sediment of yeast, beer of greater palate-fullness and inferior stability than where a slowly settling yeast is used.

Wild yeasts do not bunch together and settle like cultivated yeasts. They are therefore not so readily eliminated from the beer.

Differences in attenuation cannot be explained wholly, however, on the basis of this faculty of yeast to secrete a gelatinous mass and form bunches, and considering the importance of this matter it seems proper to give a short review of the opinions held by those who have investigated it.

CULTIVATED YEASTS AND ATTENUATION.

The cultivated yeasts employed in brewing all contain invertase and maltase, consequently all of them are capable of fermenting the sugars contained in the wort (see yeasts and sugars). Nevertheless the same wort fermented by different cultivated yeasts, results in beers of different attenuation, and this difference is so marked as to furnish a basis for classifying yeasts. Accordingly we speak of high attenuating and low attenuating yeasts, and either variety may belong to the top-fermentation or the bottom-fermentation class.

Irmisch studied two yeasts which showed marked differences as to attenuation and found that, no matter how favorable were the conditions as to complete fermentation of the sugars of the wort, one of the yeasts would leave a larger sugar remnant in the

wort than the other (Wochenschrift f. Brauerei, 1891, page 1131). The high attenuating yeast was called *Frohberg*, the lower attenuating one *Saaz*.

Arminius Bau found similar differences in attenuating power of top-fermenting yeasts when subjecting them to favorable conditions of fermentation (Chemiker-Zeitung, 1892, page 1520).

The different behavior of the two types of yeast was explained by the Berlin College of Brewing by assuming that the yeast Frohberg possessed the faculty of fermenting certain malto-dextrins of the wort, whereas yeast Saaz could not, yeast Frohberg containing an enzyme which enabled it to invert certain malto-dextrins, whereas yeast Saaz being devoid of the enzyme, was incapable of fermenting this particular malto-dextrin.

Prior disputed this theory, contending that if the difference in attenuation was due to the presence or absence of an enzyme, yeast Saaz would not *under any circumstances* be capable of fermenting the malto-dextrin in question. (Bayerisches Brauerjournal, 1895, pages 193 to 326.) He succeeded, however, in obtaining the same attenuation of wort with yeast Saaz as with yeast Frohberg by fermenting wort under vacuum at higher temperature (30° to 33° C. or 86° to 91° F.) while passing air through the fermenting liquid at the same time. Yeast Frohberg reached the final attenuation, that is, fermented the malto-dextrin in question, much quicker than yeast Saaz. Prior found, moreover, that a remnant of sugar remains unfermented even under these favorable circumstances, and that this remnant is composed in part of maltose. The conclusion is that under conditions that obtain in practical brewing there always remains a remnant of unfermented maltose as well as of malto-dextrins, which will be the smaller for both sugars, the more favorable the conditions as to temperature, aëration, yeast nourishment, etc., and which will differ also with the type and vitality of the yeast.

According to E. Fischer, the degree of completeness to which sugar is fermented, depends upon the greater or less conformity of the geometrical structure or configuration of the sugar molecule and the active agencies or enzymes of the yeast cell.

Krieger showed that the constituents of beer undergo a constant, although slow, transformation during fermentation and storage. This transformation is characterized by the increase of *reduction* and decrease of polarization, that is, by the transforma

tion of complex carbohydrates into simple sugars under the influence of some enzyme which Krieger thinks may be identical with glucase or maltase. This view was confirmed by Fischer, who showed that glucase is present as a normal ingredient of yeast. (American Brewer, 1894, p. 44.) Krieger, in an article about the degree of final attenuation of the yeasts of Saaz and Frohberg types, says: "The yeast of the type Frohberg contains an enzyme transforming slowly, but constantly, the unfermentable isomaltose into an easily fermentable kind of sugar. The type Saaz contains it in a considerably smaller degree of either activity or quantity.' (American Brewer, 1895, p. 304.)

Prior traces the causes leading to the differences in attenuating power of the yeasts Saaz, Frohberg and a third type discovered by Van Laer and called Logos, which possesses still higher attenuating power than either of the other two, to physical and physiological processes (Malz u. Bier, page 438).

The splitting up of the sugar taking place within the yeast cell, only so much sugar can ferment as reaches the protoplasm by passing through the cell membrane. Now, the membranes of the yeast cells have different thicknesses and, consequently, do not permit the diffusion or diosmosis of sugars into the yeast cell with equal facility. Hence, under equal conditions some yeasts will ferment the sugars quicker than others and more completely in the same time. Logos yeast permits the diffusion or diosmosis of certain sugars more readily than Frohberg, the latter, in turn, more readily than Saaz (see also Micro-organisms, Osmoses). Besides, yeasts have different power of reproduction, different power of resistance toward the products of fermentation, and are affected differently by aëration and temperatures, all of which factors may exert an influence on the completeness with which the sugars are fermented by different yeasts under identical circumstances.

Diffusion and, hence, fermentation, will also be retarded and a lower attenuation produced where the yeast membrane secretes substances of a slimy nature, which seems to be the case with Saaz yeast more than with Frohberg.

Prior examined three different yeasts which displayed marked differences in the rapidity of fermenting saccharose and in their behavior towards other sugars contained in wort, as maltose, dextrose, and levulose (Bayerisches Brauerjournal, 1895, page

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374). He found that saccharose ferments fastest, next dextrose, then levulose, and maltose slowest of all. This shows that different sugars pass through the yeast membranes with very unequal facility.

FERMENTATIVE ENERGY AND REPRODUCTION.

Fermentative energy or fermenting power is measured by the amount of sugar a yeast can ferment in a given time, which measurement is taken by weighing the amount of carbonic acid gas generated (see Microscopical Laboratory). Fermenting power is therefore quite distinct from attenuating power, which means the amount of sugar fermented absolutely, irrespective of time.

The physiological functions of yeast manifest themselves in two directions, viz., that of the fermentation, that is, of splitting up sugars into alcohol and carbonic acid, and of reproduction, that is, of producing new cells.

Different types of yeast show marked differences in the amount of new yeast formed and in the energy of fermentation, that is, the amount of sugar split up in a given time. These yeasts which show high reproductive energy generally display less fermentative energy, and vice versa.

Generally, fermentation and reproduction are carried on by the cell simultaneously, although yeasts can be compelled to multiply without exerting any fermentative energy, as Pasteur showed, if grown in such a nutritive solution as yeast water in the presence of a sugar it cannot ferment, as milk sugar, and, on the other hand, yeast can be caused to ferment without reproduction, as in a pure sugar solution.

The substances from which yeast reproduces its body are mainly amides and phosphate of potash. The sugar which it is called upon to split up in a wort, is mainly maltose, besides small quantities of saccharose, dextrose, levulose and malto-dextrin.

Reproductive energy, fermentative energy and attenuating power are dependent on the species of yeast in the first place, and secondly, on the physiological condition or vitality of the yeast, which in turn is dependent upon age, composition of the nourishing medium, temperature, aëration, amount of fermentation products like alcohol and carbonic acid, etc.

That fermentative energy is also largely dependent on the *species of yeast* employed was shown by Prior, who examined

large number of yeasts in respect to this point, according to the method of Meissl, obtaining the following results, which are calculated for yeast dry matter:

FERMENTATIVE ENERGY OF DIFFERENT YEASTS (PRIOR).

	Fermentative energy.
Carlsberg yeast I	136.40
Carlsberg yeast II	106.13
Saccharomyces pastorianus I	155.48
Saccharomyces pastorianus II	280.72
Saccharomyces pastorianus III	202.20
Saccharomyces ellipsoideus I	285.76
Saccharomyces ellipsoideus II	219.03
Berlin yeast, type Frohberg	170.57
Nuremberg yeast A	200.50
Nuremberg yeast R^a	232.95
Nuremberg yeast C^a	117.79
Nuremberg yeast D^a	148.99
Nuremberg yeast K^a	133.56
Nuremberg yeast Z^a	145.19
Nuremberg yeast L^a	104.84
Berlin yeast, type Saaz	113.07
Vacuolized Nuremberg yeast	203.09

The differences shown by these figures are accounted for by Prior on the theory that the cell-walls of the different yeast types are of unequal thickness and consequently permit osmose or diffusion with greater or less readiness.

Fermentative activity has an influence on reproductive activity. The splitting up of sugar must be considered a normal function of the yeast which is conducive to its well-being and consequently stimulates reproduction.

Fermentative activity of one species of yeast has a retarding influence on the reproductive activity of other species and of bacteria. Large numbers of culture yeasts in a liquid containing proper nourishment, and other conditions, will crowd out smaller numbers of other yeasts or bacteria, even if the other conditions for growth are as favorable to those organisms which are in the minority, as for the predominant one. If, however, the conditions are more favorable for the smaller number, the latter may grad-

ually obtain the upper hand and crowd out the more numerous type.

RESPIRATION.

The influence of aëration on the reproductive and fermentative energy of yeast is marked and peculiar.

Yeast absorbes oxygen with avidity and gives off a corresponding amount of carbonic acid besides the fermentation carbonic acid, as Schützenberger showed. The power of absorption of oxygen varies with the temperature. At temperatures where yeast shows the highest fermentative energy it also exhibits the highest power of absorbing oxygen, that is, at about 24° R. (86° F.), while this power gradually diminishes with lower temperatures, but is still appreciable at ordinary bottom-fermentation temperatures.

Pasteur considered fermentation as the result of a physiological process that set in if yeast was unable to obtain free oxygen, in which case it would extract the oxygen from the sugar. According to this theory, reproduction without fermentation would take place in the first stages of fermentation as long as there was free oxygen in the fluid, or at least the presence of free oxygen would result in a diminution of fermentation and an increase of reproduction. This, however, is not in conformity with the facts. A. J. Brown showed that if two fermentations are conducted under the same conditions, with the only difference that one is aërated, the other not, fermentative energy will be increased in the aërated wort, even if the conditions were such as to check the growth entirely, thus refuting Pasteur's theory. A. J. Brown and later Schützenberger found that reproduction does not take place at all if the yeast cells in a nourishing medium exceed a certain number, from which observations it may be inferred that aëration will stimulate the reproductive functions only until this maximum is reached.

In a sugar solution yeast will cause fermentation but not reproduce itself, and aëration will have no influence on the reproductive energy. For reproduction the first essential is, of course, proper nourishment, and in liquids, which contain such nourishment, as worts, aëration was found by R. Pedersen (Communications of the Carlsberg Laboratory, Nos. 1 and 2) and F. Schönfeld (Wochenschrift f. Brauerei, 1896, page 421) to have a stimulating effect on the reproductive functions, that is, more yeast w

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produced while fermentation proceeded more rapidly and attenuation was higher.

TEMPERATURES.

Yeasts may show signs of fermentative as well as reproductive activity at as low a temperature as 0° R. (32° F.). Growth stops at about 32° R. (104° F.) and fermentation ceases at about 40° R. (122° F). At temperatures below 3° R. (39° F.) some varieties of bottom-fermentation yeast are incapable of growth or fermentation. The higher the temperature rises up to a certain limit the greater becomes the reproductive and fermentative energy.

Pedersen found the most favorable temperature for the rapidity of reproduction of bottom yeast to be between 22° and 27° R. (81° and 93° F.) when cultivated in unhopped wort, while the amount of new yeast produced was found to be uninfluenced by the temperature. (Mittheilungen aus dem Carlsberger Laboratorium No. 1.)

The temperature at which yeast shows the greatest fermentative energy is about 24° R. (86° F.). It differs, however, with different species.

Yeasts survive exposure to very low temperatures. Brewers' yeast may be preserved by freezing, without injury, if the mass is allowed to thaw out gradually.

The influence of high temperatures in destroying yeast depends on the variety and vitality, whether the yeast is young or old, strong or weak. Hansen found that cells of *Saccharomyces ellipsoideus II* were killed at one time in five minutes at 44° R. (131° F.), whereas, under other circumstances they survived heating to 48° R. (140° F.) for five minutes. If carefully dried, yeast is able to withstand very high temperatures. Kayser found that moist pale ale yeast was destroyed after keeping it at 48° to 52° R. (140° to 149° F.) for five minutes, whereas, after drying, it was heated to 75° to 84° R. (201° to 221° F.) without injury. (Thausing, Malzbereitung und Bierfabrikation, 1898, page 721). Heating beer to 48° R. (140° F.) and holding this temperature for about 30 minutes effectually destroys all organisms ordinarily contained in beer. (Wahl and Henius.)

Some yeasts are much more active at comparatively low temperatures than others. Wild yeast and mycoderma are not checked

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by low temperatures to the same degree as cultivated yeasts. Low fermenting temperatures, therefore, favor their growth as against the culture yeast in beer wort. At higher temperatures the cultivated yeast is able to suppress the wild yeasts more effectually.

NUTRITION.

Yeasts can only feed on such substances as are in solution and capable of diffusion, that is, that can penetrate the membrane of the yeast cell. (See also Micro-organisms, and Bottom Yeast).

Yeast builds up its protoplasm mainly from albuminoids in the form of amides and from mineral substances, mainly phosphoric acid and potash. The sugar it splits up probably serves the same purposes as do the carbohydrates in the animal economy, furnishing the heat necessary to supply the energy to carry on the vital functions (see Micro-organisms, Assimilation). The sugars contained in beer wort are mainly maltose and smaller quantities of saccharose, malto-dextrin, dextrose and levulose. Not all yeasts can ferment all of these sugars. (See Yeasts and Sugars).

Wahl and Nilson who made exhaustive researches to determine the behavior and importance of the albuminoids in beer production, found that the amount of albumen taken up by the yeast out of the wort during fermentation under the conditions that obtain in the brewery was independent of the amount of albumen contained in the wort. (American Brewers' Review, Vol. VII, pages 35 to 37). For every 100 parts of sugar fermented, 0.28 to 0.48 parts of nitrogen, averaging 0.40, or $0.4 \times 6.25 = 2.5$ parts of albuminoids were removed from the wort. The loss of albuminoids during fermentation was found to be 22 to 55 per cent of the amount contained in the wort, or an average of one-third.

While the process of splitting up the sugar is being carried on by the yeast, the latter shows a strong tendency to develop and increase. Hence, the amount of amides and phosphates should be proportioned to the amount of sugar to be fermented. The higher the percentage of sugar in the wort and the lower the amount of amides and mineral substances—the quicker will the yeast become weakened. If the proper proportions are not observed, the cells appear less well developed, they do not unite in clusters, giving rise to the so-called "break" of the beer, hence *do not settle so* promptly or firmly.

A suitable composition of wort for the uses of the yeast is one containing the ingredients in about the following ratio:

Sugar degree 60 — 70 (S : N.-S. = 100 : 60 — 40).
Amides and peptones over 0.50 per cent.
Mineral substances, chiefly phosphate of potassium, over 0.2 per cent.

THE PRODUCTS OF ALCOHOLIC FERMENTATION.

During alcoholic fermentation sugar is split up into alcohol and carbonic acid. Besides, as Pasteur showed, small quantities of succinic acid and glycerin are formed. The presence of crystals of oxalate of lime in the yeast indicates that minute quantities of oxalic acid are regularly formed. Under certain conditions, especially at high fermenting temperatures, so-called fusel oils, among which are counted propylic, butylic and amylic alcohol, may be generated in small quantities. They have a disagreeable taste, and seem to be regularly produced in the distillers' fermentation. They can be removed from the spirits by repeated distillation. Under ordinary circumstances and normal conditions of fermentation these fusel oils were found by Rayman and Kruis to be absent in beer where pure culture yeasts were employed (Prague, 1891). According to Bechamp and Duclaux acetic acid is always present in wine and beer in small quantities and is to be considered a regular product of alcoholic fermentation.

According to Pasteur 100 parts of saccharose yield: Alcohol, 51.01 per cent; carbonic acid, 49.12 per cent; glycerin, 2.5 to 3.6 per cent; succinic acid, 0.5 to 0.7 per cent.

Jodlbauer found the following amounts of alcohol and carbonic acid generated (Zeitschrift f. d. ges. Brauwesen, 1888, p. 252):

	Alcohol.	Carbonic acid.
For Saccharose...............	51.11 per cent	49.03 per cent
For Maltose (anhydrous)....	51.00 per cent	49.04 per cent
For Dextrose	48.07 per cent.	46.54 per cent

Prior determined the amounts of volatile (other than carbonic) and fixed acids generated during fermentation with 17 different yeasts (Malz und Bier, 1896, pp. 401 and 402).

The results are summarized by Prior as follows:

1. In the fermentation of pure hopped and aërated malt worts with the 17 yeasts examined volatile and fixed organic acids were *produced in considerable* quantities.

2. The amounts of the acids generated differ for different yeasts, ranging from 4.7 to 10 c.c. decinormal soda solution per 100 c.c. fermented wort. (See table, page 546.)

3. The amounts of fixed organic acids (succinic?) generated lie between 2.1 and 5.4 c.c., those of the volatile organic acids between 2.1 and 5.8 c.c. decinormal solution for 100 c.c. wort.

4. The percentage of primary potassium phosphate diminishes slightly, corresponding to 0.012 to 0.005 g. phosphoric acid (P_2O_5) per 100 c.c. wort.

5. For every 100 c.c. decinormal soda to neutralize the fixed organic acids, there is required to neutralize the volatile acids:

For Nuremberg yeast Rª	92.3 c.c.
For Nuremberg yeast Lª	88.0 c.c.
For sacch. ellipsoideus I	105.9 c.c.
For sacch. ellipsoideus II	131.0 c.c.
For sacch. pastorianus I	180.9 c.c.
For sacch. pastorianus II	107.2 c.c.
For sacch. pastorianus III	126.0 c.c.
For Carlsberg yeast I	83.3 c.c.
For Carlsberg yeast II	63.6 c.c.
For Berlin Saaz yeast	52.4 c.c.
For Berlin Frohberg yeast	80.0 c.c.
For Nuremberg yeast A	58.3 c.c.
For Nuremberg yeast vacuolized	84.8 c.c.
For Nuremberg yeast Cª	73.0 c.c.
For Nuremberg yeast Dª	113.3 c.c.
For Nuremberg yeast Kª	72.2 c.c.
For Nuremberg yeast Zª	85.2 c.c.

Thus, while the amounts of fixed organic acids exceed those of the volatile acids, except for the cultivated yeast Dα, the wild yeasts (sacch. pastorianus and ellipsoideus) exhibit the opposite relation, the volatile acids exceeding the fixed ones, in the case of pastorianus I by a considerable amount.

The quantity and nature of the products of alcoholic fermentation vary according to conditions, as temperature, fermenting period, composition and concentration of liquid, vitality of yeast, type of yeast.

Besides the above named substances, there are sometimes formed substances in small quantities that become noticeable on account of the peculiar odor they impart to the fermented liquid.

ACIDS IN WORTS FERMENTED WITH DIFFERENT YEASTS, EXPRESSED IN C.C. DECINORMAL SODA SOLUTION PER 100 C.C. WORT.

	Original Wort.	Ra	La.	Sacch. Ellips. I.	Sacch. Ellips. II	Sacch. Past. I.	Sacch. Past. II.	Sacch. Past. III.	Carlsb. I.	Carlsb. II	Saaz.	Frohberg	A.	Vacuo-lized.	Ca.	Da.	Ka.	Za.
Total acid	19.4	23.2	23.0	25.8	25.0	24.6	26.8	29.0	24.8	25.4	24.8	26.2	26.8	27.6	28.4	29.2	29.0	29.4
Volatile acids	1.7	4.1	3.9	5.30	5.5	5.5	6.3	7.5	4.2	3.8	3.9	4.9	4.5	5.6	5.5	6.8	5.6	6.3
Fixed organic acids	4.1	6.7	6.6	7.5	7.0	6.2	8.4	8.7	7.1	7.4	8.3	8.1	8.9	8.7	9.3	8.6	9.5	9.5
Primary phosphate	13.6	12.9	12.7	12.6	12.4	12.7	11.9	12.3	12.5	12.9	12.1	12.7	12.8	12.3	12.5	12.5	12.7	12.6
P_2O_5 calculat'd	0.097	0.092	0.090	0.090	0.088	0.090	0.085	0.087	0.089	0.092	0.086	0.090	0.091	0.087	0.089	0.089	0.090	0.09
P_2O_5 detected	0.097	0.090	0.094	0.096	0.093	0.098	0.092	0.091	0.094	0.094	0.091	0.080	0.090	0.090	0.088	0.086	0.090	0.080

AMOUNTS OF FIXED AND VOLATILE ORGANIC ACIDS GENERATED, EXPRESSED IN C.C. DECINORMAL SODA SOLUTION PER 100 C.C. OF WORT.

	Ra.	La.	Sacch. Ellips. I.	Sacch. Ellips. II.	Sacch. Past. I.	Sacch. Past. II.	Sacch. Past. III.	Carlsb. I.	Carlsb. II.	Saaz.	Frohberg.	A.	Vacuo-lized.	Ca.	Da.	Ka.	Za.
Total acid	5.0	4.7	7.0	6.7	5.9	8.9	10.4	5.5	5.4	6.4	7.2	7.6	8.5	9.0	9.6	9.3	10.0
Volatile acids	2.4	2.2	3.6	3.8	3.8	4.6	5.8	2.5	2.1	2.2	3.2	2.8	3.9	3.8	5.1	3.9	4.6
Fixed organic acids	2.6	2.5	3.4	2.9	2.1	4.3	4.6	3.0	3.3	4.2	4.0	4.8	4.6	5.2	4.5	5.4	5.4

[redacted]

Thus sulphuretted hydrogen is produced under certain circumstances by some types of brewers' yeast even where a pure culture is used, giving rise to the so-called onion taste of beer. Wild yeasts give a different flavor to beer than culture yeasts and Brefeld remarks that the peculiar aromatic products which give to wine and beer much of their character are developed mainly during after-fermentation when the yeast has reached a condition of low vitality and is at the point of death (Landw. Jahrbuecher, 1875 and 1876). Pure cultures of different yeast types are known, however, to yield beers that can be plainly distinguished by differences in aroma (fruit-like) without aging, which is undoubtedly due to the generation of ether-like substances. In the case of a certain yeast type this aroma resembles that of apples, in another that of pineapples. The onion flavor also belongs in this class.

In growing and reproducing itself the yeast forms protoplasm and cellulose which, therefore, must also be counted among the products of fermentation.

By the splitting up of the sugar into alcohol and carbonic acid, heat is produced. A part of the heat developed during fermentation is caused by the mixing of the alcohol in the measure as it is produced with water. The heat generated is utilized by the yeast in carrying on its vital functions, a part is made latent in the building up of new substance, while a part escapes with the carbonic acid. The remainder goes to heat the liquid.

INFLUENCE OF FERMENTATION PRODUCTS AND OTHER AGENCIES ON YEASTS.

The products resulting from fermentation by yeast, as alcohol and carbonic acid, and those produced by bacteria fermentation, as lactic and butyric acids, retard fermentation and growth. They act like poisons on the organisms that generated them.

ALCOHOL.

The greater the quantity of alcohol produced and remaining in the liquid the greater will be its retarding influence until finally fermentation will be completely checked. The amounts of alcohol necessary to stop fermentation completely vary with different yeasts and with the vitality of the yeast. Dr. Lindner examined different yeasts in this direction, pitching 29 per cent solutions of maltose with different yeasts (Mikroskopische Betriebscontrolle,

page 112). Top-fermentation yeasts were found to yield from 9 to 15 per cent by volume of alcohol. Yeast Saaz produced a little over 8 per cent, Frohberg not quite 11 per cent.

Beer worts do not contain enough sugar to yield such high percentages of alcohol, hence fermentation in the brewery does not receive a complete check from the alcohol produced. In sweet wines, on the other hand, the amount of alcohol produced is sufficient to bring fermentation to a full stop.

CARBONIC ACID.

Only a small portion of the carbonic acid developed during the fermentation remains in the beer, the bulk of it passing off into the surrounding air. Later, when the beer is bunged, it holds absorbed an amount proportionate to the bunging pressure. Lintner found carbonic acid retards fermentation and that an addition of carbonic acid aids in preserving beer. (Zeitschrift f. d. ges. Brauwesen, 1885, page 100). If fermentation is carried on in closed vessels under pressure the growth of yeast and fermentation are retarded at the same time. Whether the fermentative energy of the individual cell has been decreased cannot however be deduced from this observation. According to Foth, who carried out a series of fermentations under pressure and in vacuo, the carbonic acid exerts a distinct influence on the physiological functions of the yeast, resulting in slower fermentation (Wochenschrift f. Brauerei, 1887, page 73); whereas, Hansen concluded from the experiments of Foth that the fermentative energy of the individual yeast cells is increased under pressure, while only the reproductive energy is decreased. (Centralblatt f. Bakteriologie u. Parasitenkunde, 1887).

EFFECT OF ACIDS.—ANTISEPTICS.

Generally speaking, acids retard the growth of all organisms. An exception to this rule is lactic acid, which retards the growth of bacteria, but in the quantities that are contained in beer does not seem to check the growth of yeast or its fermenting power. Maercker found that ½ per cent of lactic acid had a favorable influence on the growth of yeast; 1 per cent was without injurious influence, but 3½ checked it completely; ½ per cent of acetic acid influenced fermentation perceptibly, while of butyric acid 0.05 per cent was sufficient (Zeitschrift f. Spiritusindustrie, 1881, No. 7).

The small quantities of lactic acid in wort and beer, th fore, have no retarding influence on the growth of yeast. P teur showed that in neutral nourishing media or such as slightly alkaline, the growth of bacteria is favored, while in sol tions slightly or strongly acid, like grape juice, saccharomyc will flourish and be better able to suppress bacteria than i neutral or alkaline solutions. Wahl and Henius found that neu tral or alkaline beer worts generally yield beers that are more strongly infected than those derived from normal, that is, slightly acid worts, showing that in the latter class the lactic acid hinders the growth of bacteria.

Alcohol, carbonic acid, lactic acid and the soft hop resins may be called the natural preservatives of wort and beer.

Lafar found that of 15 species of yeast, all were able to carry on fermentation in the presence of 0.78 per cent acetic acid, whereas, fermentative and reproductive energy were influenced in different degrees, while in the presence of 1 per cent of acetic acid fermentation was checked completely with three of the species.

Many acids, as tartaric, salicylic, carbolic and fluoric acids affect cultivated yeast more detrimentally than they do wild yeast and Hansen showed that, whereas tartaric acid effectually checked the development of bacteria in impure yeast, the percentage of wild yeast increased during fermentation. Similar results were obtained by Joergensen and Holm with fluoric acid (Zeitschrift f. d. ges. Brauwesen, 1893, page 126). The conclusion seems justified, therefore, that these acids cannot safely be used to purify yeast, except to free it from bacteria.

Exhaustive studies were made by Will concerning the influence of various antiseptic bodies on different cultivated yeasts, wild yeasts and bacteria (Zeitschrift f. d. ges. Brauwesen, 1893 and 1894). According to his findings, all yeasts are destroyed by the presence of 0.1 per cent of sublimate, 0.4 per cent of sulphurous acid (SO_2), 0.2 per cent of chlorine, 5 per cent of alcoholic salicylic acid solution.

Very small quantities of antiseptic substances have in some instances a stimulating effect on the growth of yeast. This applies to salicylic and fluoric acids.

Salts of the heavy metals, such as copper, iron, mercury, lead

and others, have a poisonous effect on yeast. Especially does this seem to be the case with lead.

Prior states that he found fermentation appreciably retarded in a pure yeast apparatus on account of the presence of lead in the tin coating of the interior of the apparatus (Bayerisches Brauerjournal, 1893, p. 2).

Concentrated sugar solutions may destroy the reproductive and fermentative energy of yeast. In weak sugar solutions fermentation remains incomplete (see page 537).

AUTO-FERMENTATION OF YEAST.

Yeast standing at ordinary temperature and still more quickly at somewhat higher temperatures (about 25° R. or 88° F.) will generate carbonic acid gas and speedily become weakened to the point of destruction. Being deprived of sugar, it seems to ferment its own substance, chiefly the glycogen, which is inverted into dextrose, and fermented.

PUTREFACTION OF YEAST.

Dead yeast easily putrefies on account of the large amount of albuminoids it contains which are readily decomposed by bacteria. The substances produced by this putrefaction are similar to those generated from animal matter by analogous processes.

Yeast may become putrid if standing under beer or water, in which case it will give off the products of putrefaction to the liquid.

On account of the readiness with which yeast putrefies and goes into auto-fermentation, it can be preserved or shipped without injury only with great difficulty, the methods employed being based on refrigeration, the removal of water, the addition of substances to absorb the water, addition of antiseptics.

CHEMICAL COMPOSITION OF YEAST.

Brewers' yeast is composed of countless cells that mechanically enclose between them a large amount of beer or water, some proteids, some hop-resin and particles of cellulose from malt husk and hops. The yeast cells themselves, after removing the mechanically adhering water, still contain about 80 per cent of water as a constituent part of the protoplasm and cell-membrane.

Besides water, the yeast cell contains carbohydrates, nitrogenous *substances, fat and* mineral substances.

CARBOHYDRATES.

CELLULOSE.

The cell-membrane is composed mainly of cellulose, which, like other vegetable cellulose, can be changed into sugar by the agency of acids. It does not, however, dissolve in an ammoniacal solution of cupric oxide, which is a characteristic of cellulose derived from the higher plants. The amount of cellulose has been estimated as 18 to 32 per cent of the weight of the dry yeast substance.

YEAST MUCILAGE.

Hansen discovered that yeast develops a mucilaginous coating in which the yeast cells become imbedded, causing them to cling together and form bunches.

The power of forming this coating undoubtedly corresponds in a measure to the rapidity with which yeast settles, and also gives rise to the phenomena known as "break" or "Bruch" of the beer. This mucilaginous substance is converted into dextrose by acids.

YEAST GUM.

Yeast gum has been obtained by Lintner by boiling yeast with water (Zeitschrift f. d. ges. Brauwesen, 1890, p. 476). Hessenlund obtained about 6.5 per cent of gum by boiling yeast with lime, and Salkowsky obtained, from distillers' pressed yeast that was free from starch, a white powder soluble in water, very much like gum arabic. (Ber. d. deut. chem. Gesellschaft, 1894, p. 497.)

GLYCOGEN.

Glycogen may be considered a reserve material for animals and yeast, as starch is for the higher plants. It may accumulate in the yeast as Laurent found, to the amount of 32.6 per cent of the dry substance (Botanische Zeitschrift, No. 48, p. 719). In the absence of sugar, yeast will ferment glycogen after inverting it to dextrose. This it does when yeast is stored, for instance, where it is kept at higher temperatures, in which case it undergoes auto-fermentation (Cremer, Zeitschrift f. Biologie, No. 31).

NITROGENOUS CONSTITUENTS OF YEAST.

Of nitrogenous bodies, yeast contains proteids, albumose, peptones, amides, nuclein and enzymes.

According to Naegeli and Loew the plasma of a young yeas
yields about 75 per cent of proteids and about 2 per cent of pe

tones, but if the yeast is dried nearly all of the proteids are changed to peptones (Sitz. d. bayer. Acad., 1878, part II). A yeast containing 8 per cent of nitrogen was analyzed with the following results:

Cellulose and yeast mucilage		37 per cent
Proteids	Albumin	36 per cent
	Substances resembling gluten-casein	9 per cent
Peptone (precipitable by acetate of lead)		2 per cent
Fat		5 per cent
Ash		7 per cent
Extractive substances		4 per cent

The extractive substances included invertase, leucin, dextrose, glycerin, succinic acid, guanin, xanthin, sarkin, alcohol and probably traces of inosit.

In 14 yeasts the amount of nitrogen found varied from 7.00 to 9.91 per cent, equivalent to 43.75 to 61.97 per cent proteid substance figured on a dry basis. (VI Ber. d. Münch. wiss. Station.)

NUCLEIN.

Nuclein is a proteid and seems to be a normal constituent of the nuclei of cells. It is a white amorphous powder, containing a much higher percentage of phosphorus than other proteids.

A. Stutzer obtained nuclein from yeast by extracting it with alcohol of 95 per cent strength. He found the yeast to contain, figured on a dry basis:

Total nitrogen	8.648
Proteids, nitrogen	7.773
Nuclein, nitrogen	2.257

As to the amount of nuclein or some other remedial agent in yeast, it may be mentioned that Dr. Baecker of Paris, in a paper read before the International Medical Congress, at Rome, 1899, presented a series of observations on the treatment of certain infectious diseases by means of sterilized (pure) yeast cultures, the results having proved extremely favorable. "'Yeast,' or 'barm,'' as an empirical remedy purely," says the *Medical Age*, "in days gone by, won for itself golden opinions in typhoid, diphtheria, consumption and other maladies."

Professor Vaughan of Ann Arbor was the first to make experiments on animal and man to determine the effect of yeast nucleinic acid upon the number of white blood-corpuscles (Trans-

actions of the Michigan State Medical Society for 1894). The experiments therein referred to were begun in 1892.

Nuclein (nucleinic acid) is now generally used by the medical profession and manufactured on a large scale by Parke, Davis & Co. of Detroit, Mich.

YEAST ENZYMES.

All culture yeasts contain at least three enzymes, namely: Invertase, which has the power of inverting saccharose to dextrose and levulose; maltase which has the power of inverting maltose to dextrose (see Yeasts and Sugars), and zymase which, according to Buchner's theory of fermentation, splits sugar into alcohol and carbonic acid and is really the agent in the yeast cell to whose activity fermentation is due. (See History of Theory of Fermentation, page 530.)

Bottom fermentation yeasts contain another enzyme that is not found in top yeast, namely, melibiase. (See Yeasts and Sugars.)

These enzymes are nitrogenous bodies.

YEAST INVERTASE.

Invertase can be obtained by extracting yeast with water and precipitating it out of the aqueous solution by means of alcohol, and drying over sulphuric acid. (Barth, Ber. d. deut. chem. Gesellschaft, 1878, p. 474.) The most favorable temperature for the action of this enzyme on saccharose lies between 42° and 45.5° R. (126.5° and 134.5° F.). At 56° R. (158° F.), its action ceases. The action of invertase on a sugar solution increases with the strength of the solution up to 20 per cent. Wine and beer contain traces of invertase. According to J. O'Sullivan this enzyme cannot be extracted by water from some yeasts.

YEAST MALTASE OR YEAST GLUCASE.

This enzyme can be extracted from yeast by treating dry yeast powder with lukewarm water (Emil Fischer, Ber. d. deut. chem. Gesellschaft, 1894, pp. 2986 and 3479). The filtered solution will invert maltose and malto-dextrin to dextrose. Its most favorable temperature of inversion is 32° R. (104° F.). Lintner and Kroeber have shown that yeast glucase is not identical with the enzymes of the same name contained in barley, and especially in maize, the latter enzyme, according to Geduld, being most *favored in its action* by temperatures from 45.6° to 48° R. (134° *to 140°F.).*

FOR YEAST MELIBIASE SEE "YEASTS AND RAFFINOSE," PAGE 535.

YEAST ZYMASE.

This enzyme was obtained by Buchner by rupturing the yeast cell by means of grinding pressed yeast with sharp sand and then subjecting the moistened mass to a strong pressure. After filtration and removal of all particles in suspension by means of the centrifugal machine, the solution has the power of splitting up sugar into alcohol and carbonic acid, thus proving that an enzyme is present in the solution effecting the splitting up of the sugar, and that fermentation is not dependent on the presence of the living yeast cell.

The expressed yeast juice, obtained as above, is very sensitive. Upon being heated, it coagulates and loses its efficiency. With prolonged preservation it also loses its fermenting power.

By evaporating the juice at a low temperature in vacuo, zymase may be obtained in a dry state. While it is weakened, it does not lose its sugar dissociating power. Zymase may also be precipitated by alcohol, and the sediment possesses some fermenting power though much weakened.

PROTEOLYTIC ENZYME IN YEAST.

Yeast also seems to contain enzymes resembling peptase in their action. The investigations of Will, who examined 27 kinds of yeast as to their property of peptonizing albumen lead him to the following conclusions (Ztschr. f. d. ges. Brauwesen, 1898, pg. 182):

1. Every one of these 27 varieties of yeast is capable of liquefying gelatin.

2. The energy of peptonization depends on the type of the yeast, the method of inoculation and the temperature.

3. The liquefaction takes place more rapidly when the yeast is uniformly distributed.

4. The liquefaction must be regarded as a function of vigorously vital cells brought about by the deficiency in nourishment and oxygen.

YEAST FAT.

Naegeli determined the amount of fat contained in yeast to be about 5 per cent of its dry substance. Kulish found yeast fat to consist of phytostearin and glyceride of myristic acid (Weinbau Weinhandel, 1891, p. 250).

MINERAL SUBSTANCES.

The amount of ash contained in yeast has been variously determined by different chemists as 2.5 to 9½ per cent of the dry substance.

The principal ingredients of the yeast ash are potash (28 to 39 per cent) and phosphoric acid (44 to 55 per cent). Magnesia has been found in quantities of 4 to 8 per cent, lime 1 to 4½ per cent, besides small quantities of silicic, sulphuric and muriatic acid and oxide of iron.

YEAST EXTRACT LIKE MEAT EXTRACT.

A yeast extract, resembling extract of beef in its properties, is the basis of a patent granted to Robert Wahl and Max Henius in the United States of America in 1895. To produce it, the inventors heat the yeast to boiling point, whereby the yeast cells are destroyed and their membranes broken, freeing their contents to permit them to become dissolved in the water with which the yeast was previously mixed. The liquid portion of the resultant decoction is separated from the particles in suspension by precipitation, decantation or filtration. The liquid is then condensed in vacuo.

Since the priority of recognizing the similarity between an extract of yeast and an extract of meat has been repeatedly claimed by others years after the granting of the above patent, the specification of the latter may be cited as follows:

"Our yeast food product, since it contains a large proportion of easily digestible peptones and phosphates, affords a very desirable tonic for the human system, and we desire to be understood as intending it also for such use. Its qualities and stimulating action on the human system may be compared with those of beef extract, it being useful for culinary, as well as medicinal, purposes, and the very high percentage of phosphates it contains, and especially of phosphate of potash, renders it a peculiarly effective tonic."

This extract of yeast has been placed on the American market, being used in place of extract of beef, over which it takes preference dietetically on account of its purely vegetable origin. A analysis made by A. Nilson gave the following results:

Specific gravity	1.260
Water and volatile substances	47.90 per cent
Dry extract	52.10 per cent
Consisting of:	
Total albuminoids (49.33 per cent of dry extract).	25.70 per cent
Ashes (19.79 per cent of dry extract)	10.31 per cent
Glycerin, succinic acid, caramel, dextrin, glycogen, bassorin (30.88 per cent of dry extract)	16.09 per cent
The albuminoids consist of:	
Albuminoids precipitated by sulphate of zinc (albumoses)	3.37 per cent
Albuminoids precipitated by sodium phosphotungstate minus precipitate of zinc sulphate (peptones proper)	9.25 per cent
Albuminoids not precipitated (amides by difference)	13.08 per cent
The ash contains:	
Magnesium and calcium phosphates	0.63 per cent
Potassium pyrophosphate	6.99 per cent
Chlorine	0.19 per cent
Calculated as:	
Sodium chloride	0.31 per cent
Sulphates	a trace
Potassium carbonate (formed by ignition from organic potassium salts)	2.38 per cent

This liquid yeast extract can be readily evaporated to dryness, and forms a rather hygroscopical brown, lustrous mass which is obtainable either in flakes, when dried in thin layers on glass, for instance, or as a powder, which can readily be compressed into lozenges, tablets, etc. The similarity of the product with beef extract is remarkable, not only as to composition, but also as to general appearance and flavor. In regard to the flavor, however, it may be said that the yeast extract more closely resembles fresh beef broth than does beef extract itself.

PURE YEAST CULTURE.

By pure yeast is meant a yeast derived from a single cell by methods excluding the possibility of infection.

If yeast is mixed with the wort in the brewery and allowed to ferment in open tubs, it is evident that bacteria, wild yeasts and mycoderma that may be present in the air are apt to fall into the fluid, where they have opportunities to develop and subsequently settle, in part, in the yeast sediment.

The Old Way.—In former years, no special pitching yeast was employed, the wort being simply left to spontaneous fermentation. Frequently the fermenting tubs were not cleaned out, and the new wort was pumped on the old sediment. This operation being repeated a number of times, the sediment would acquire a certain characteristic composition. If the beer turned out satisfactory, the yeast was not thrown away when the tubs were cleaned, but was transferred to other vessels. In that way the barm gradually grew up. What this barm really was, no one knew.

Investigation of Yeast.—Inquiry into the nature of this body grew active with the improvement of the microscope, which about the beginning of the nineteenth century became an important factor in scientific research. Being applied to yeast, this mass was found to be composed of countless numbers of very small cells, each of which constitutes a living being very prolific in multiplication and endowed with the peculiar power of inciting fermentation.

PASTEUR'S PURE YEAST.

The full import of these investigations was not realized until Pasteur startled the scientific world with his classical experiments which demonstrated conclusively that the yeast mass is mixed

large numbers of cells still smaller than those of the yeast :r, and that these minute cells were bacteria. He described 'al varieties or species of these micro-organisms as being ca- : of causing beer diseases, and he advised brewers to seek eep them out of their yeast, for which purpose he devised a hod to remove them or make them harmless. This method sisted in treating the yeast with tartaric acid, which killed the :teria and resulted in what was, in a sense, a pure yeast, that is, nparatively free from bacteria.

Pasteur's pure yeast, however, never acquired any practical im- rtance. This was due to the fact, not at first understood, that is mass, while consisting practically altogether of yeast without ıy appreciable admixtures of ferments of other classes, was by o means of uniform composition, but contained different varieties f yeast, many of which, present in large quantities, were just as langerous to beer as the bacteria, although in different ways. These yeasts were afterward called wild yeasts. They are able to produce certain beer diseases, as turbidity and offensive odor and taste.

HANSEN'S PURE YEAST.

Wild yeasts were first found to be the causes of beer disease by Hansen, who traced turbidity in certain Danish beers to their presence.

Hansen set himself to discover means to produce a yeast that should be absolutely free from any admixture of wild yeast, and came to the conclusion that the only way to produce such a yeast with absolute certainty was to develop the yeast from a single cell under conditions that excluded the possibility of infection. This is what is known as Hansen's pure yeast. (For methods of preparing pure cultures see "The Brewer's Microscopical Laboratory.") For obtaining pure cultures of yeast Hansen's moist chamber method is preferable.

Selecting the Type.—The peculiar character of a beer yeast is due mainly to that variety which preponderates in the yeast, and among the pure cultures obtained from the propagation of a number of individual cells taken from such yeast it is natural that a majority should have the characteristics of the original yeast. Each pure culture is examined first as to the degree of attenua- on, whether high or low, next as to clarification, whether rapid

or slow, and also as to the taste which it imparts to the beer. If among the pure cultures are found several that show the same degree of attenuation and the same clarifying power and taste of beer that was observed in the original yeast, the conclusion will be justified that these are the ones that exert the desired influences, and it will be proper to select one of them for propagation.

Propagating the Yeast.—The yeast type that has been thus selected is propagated as described in connection with the pure yeast apparatus, until a sufficient quantity has been developed to start a fermenter in the brewery with it. Since it is not always certain that the first fermentation will take a strictly satisfactory course, it is advisable to finish the beer from this fermenter and judge the yeast by the character of this beer when finished. If the beer gives satisfaction, the yeast is introduced for permanent use.

Before this is done, a standard culture is prepared for future reference. A few drops of the yeast are placed in a vial with a sterilized 10 per cent sugar solution, and kept in a dark place. In this way the yeast can be kept unchanged for years.

Advantages of Pure Yeast.—The great advantage of pure yeast in brewing operations consists mainly in the fact that the brewer has at all times at his disposal the same identical yeast type. Consequently, he is able, other things being equal, to produce a beer of constant, uniform character. Even if the yeast should become infected or deteriorate from any other cause, a fresh batch of the identical original yeast can be developed in a few weeks from the reserve culture, and a yeast of the same properties as was possessed by the first lot be once more introduced, the reserve culture having been derived from the same original cell as the first lot of pitching yeast.

Pure yeast, however, is valuable in other ways also. It is a rule that admits of general application, that micro-organisms of one species will crowd out organisms of another species contained in the same nourishing liquid, the more effectually, the greater their relative number. In the same way, a pure yeast containing no foreign organisms, is much more resistant to disease and infection than a common mixed yeast. A pure culture yeast can be infected only by uncleanliness or by germs contained in the air, while common brewers' yeast is in itself a most prolific hotbed of infection, being frequently contaminated with bacteria, wild yeast

and mycoderma, which spring into action at slight changes of temperature or composition of yeast food, while a pure yeast will adapt itself more readily to such changed conditions.

PURE YEAST APPARATUS.

An apparatus for the development of pure culture yeast was devised by Hansen. His own description, from "Practical Studies in Fermentation," follows:

HANSEN'S APPARATUS.

As shown in the accompanying illustration, the apparatus consists of two main portions and the connecting tubes, namely: The fermenting cylinder C, and the wort cylinder D. Air pump and air holder are not shown in the drawing.

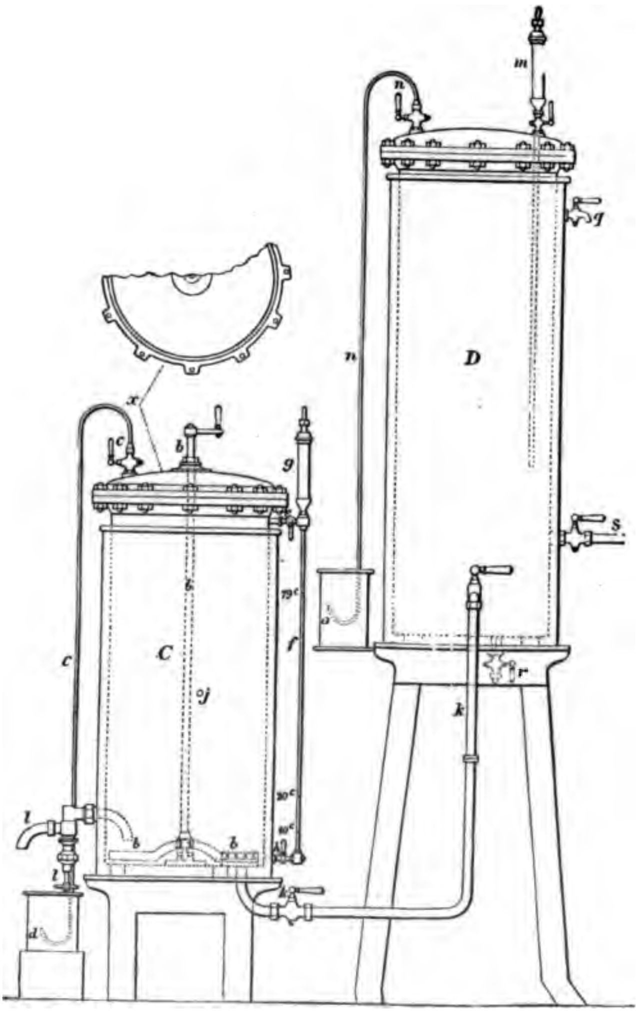
The pump A is driven by machinery and draws the air through a filter in order to effect a preliminary purification. The air-holder B is provided with a pressure-gauge and a safety valve. It is charged with air under a pressure of 1 to 4 atmospheres. The pipes must be fitted with cocks at suitable points for removing the water which collects in them. This is of especial importance in the case of the pipe between the air-holder B and the filters *g* and *m*. These are best united by metal tubes with the air pipes. If metal tubes are used, they should naturally possess some degree of elasticity and must be so arranged that the filters can be readily fitted and disconnected.

Through the top of the fermenting cylinder *C* passes a stirrer *b*, the lower end of which is fitted with two blades, one carrying a sheet of rubber cut in such a way that when rotated it comes into contact with both the bottom and the sides of the cylinder. From the top there passes a doubly bent tube *c*, and by opening its cock, connection is made with the inside of the cylinder. The lower free end of the tube dips under water in the vessel *d*.

A little below the top is a horizontal tube *e* provided with a cock, and by means of which the inside of the cylinder is connected with the vertical glass tube *f*. This is connected at its upper end with the filter *g* and at its lower end with a second cock and similar horizontal tube *h* to that described above.

The top mark on the glass tube is 31.3 in. from the bottom of the cylinder, the next 8 in. and the lowest 4 in. from the bottom of the cylinder. When filled to the top mark, the cylinder holds about 1½ barrels. The glass tube is fixed into the cocks

[redacted]



Hansen's Pure Yeast Apparatus.

e and *h* by a packing of hemp or cottonwool with vaseline; rubber is not suitable, as it is hardened by steam.

The filter *g* consists of a metal capsule containing a tightly packed plug of cotton-wool 8⅔ in. long and 1⅕ in. in diameter. This plug consists of at least one-thirteenth pound of cotton-wool; the addition of a little more is immaterial. If firmly pressed in, the capsule will hold one-ninth pound and more, but this is not necessary. The filter is closed above by means of a cover which is screwed on and which is connected with the tube from the air-holder. Before the filter is screwed on, it is sterilized by heating it for two hours at a temperature of about 302° F. (120° R.).

At the opposite side of the cylinder there is a small tube *j* scarcely ⅜ in. long and fitted with rubber tubing, the latter being closed by means of a pinch-cock and a glass stopper. Passing from the bottom of the cylinder is a tube *k* through which connection can be made with the wort cylinder D; this tube is made in two pieces to prevent too great rigidity, and in addition to the two large cocks shown, it is provided with two smaller ones which are made use of during the process of steaming described below, partly for running off the condensed water and partly for introducing the steam.

The cock shown at *l* is for withdrawing the beer and the yeast. The valve is screwed down in opening the cock and is screwed up when this is closed. In the figure it is closed. Its construction prevents infection from occurring whilst the liquid is being drawn off, as the liquid cleanses the cock on passing through it. The pipe carrying the cock is carried through the side of the cylinder and is bent toward the bottom, its end being 1⅓ in. above the latter. It is, in short, so arranged that no air from without can enter the cylinder whilst the contents are being drawn off.

The wort cylinder D must be raised somewhat above the level of the fermenting cylinder. (The wort can, of course, also be forced into the fermenting cylinder by means of compressed air, but in this case the wort cylinder must be provided with a safety valve.) Its height is also greater than that of the latter, but its diameter is the same. At the top is a filter *m* exactly as at *g*, and connected with it is a pipe (indicated by the dotted lines) passing inside the cylinder. The lower closed end of this pipe has some small perforations through which the air finds an exit

[redacted]

after passing through the filter. The tube *n* corresponds with the tube *c* of the first cylinder, and like the latter its open end dips into a vessel of water *o*. In the case of the wort cylinder it is very important that the bore of the tube *n*, and of its cock, should not be too small, in order that they may not become choked by hops or other matter; a suitable diameter for the tube is ½ in. Around the upper portion of the cylinder, a little below the top, there is a pipe in the form of a ring *p*, the inner side of which is provided with small perforations. One end of this pipe is closed and the other is connected with a cold-water tap. In addition to the cocks on the connecting pipe *k* between the two cylinders, the wort cylinder has three others *q, r, s*. The cock *s* is for the introduction of the wort, and is put in connection with the wort main *u* between the copper and the cooler. The cylinder stands in a shallow tray provided with an outlet *t* for the water which flows over the sides of the cylinder, whilst the latter is being cooled. The dotted lines at *t* show the bars on which the cylinder rests, and also the ring-like portion and bottom of the cylinder.

If the fermenting cylinder is not standing in a room with even temperature it is necessary to arrange the fermenting cylinder in such a manner that the temperature of the liquid contained in it could always be controlled, and that it could be lowered when desired. This is done by means of the jacket, shown in C, which surrounds not only the sides but also the bottom of the cylinder; the bottom of the jacket is fixed with screws and can without much difficulty be removed when it requires cleaning. For the introduction of a thermometer there is a tubular aperture through the jacket and the side of the cylinder. The jacket is provided with a tap near the bottom, forming the inlet for the cold water, and another near the top and on the opposite side for its exit; a third tap at the bottom serves for removing the sediment which is gradually deposited by the water.

The wort cylinder is here also provided with a jacket, which, however, can very well be omitted, as the perforated ring serves the same purpose sufficiently well. Nevertheless the jacket has the advantage that it encloses the water from the ring so that the operator is not liable to be splashed. It adds, however, considerably to the cost of the cylinder, and it makes it less simple to *manipulate.*

The middle portion of the cover is made of copper and is provided with a brass flange with twelve bolt holes. Between the cover and the collar of the cylinder a rubber washer is inserted and fits into a groove; a perfectly air-tight joint is thus ensured.

In order to prevent the stirrer being raised out of its bed at the bottom of the cylinder whilst in use, a ball-socket is provided. The axis ends in a ball which rests in a hemispherical socket, and two pieces accurately fitting the upper portion of the ball are bolted on; the axis can be rotated but cannot be raised from its socket.

With regard to the tinning of the cylinder, it must be pointed out that the tin should not contain an appreciable amount of lead. If this is the case, the yeast grown in the apparatus will according to Prior, be unsatisfactory.

In putting up the apparatus, it ought above all to be borne in mind that it should remain in its position undisturbed. When possible, it will generally be best to place it in the fermenting cellar. There is then, as a rule, no trouble with regard to regulating the temperature, and in drawing off the beer and the yeast there will also be less work involved, for those occupied can in the interval, do other work close at hand. If the temperature of the fermenting cellar is below 43° F. (5° R.) it is advisable to have the fermenting cylinder jacketed. In putting up the apparatus it is, of course, necessary at once to consider whether one or two fermenting cylinders are to be employed; in any case a single wort cylinder will suffice.

The apparatus having been fixed, it is necessary in the first place to test whether the cylinder is tight. To do this, steam is cautiously introduced through *k*, whilst the other cocks are closed; water-pressure may also be employed.

STERILIZING THE APPARATUS.

Before the apparatus is set working it is necessary thoroughly to sterilize the two cylinders, the pipe which unites them, and also the pipe through which the wort passes on its way to the wort cylinder. This is done by blowing a strong current of steam through the whole. The filters are sterilized, as already mentioned, in a sterilizing oven. The fermenting cylinder is sterilized by steam, admitted through one of the cocks on the

[redacted]

pipe *k*. Whilst the high tension steam is passing, the different cocks are opened from time to time, so that it can escape through these as well as by the bent tube *c*; this operation takes half an hour. Shortly before this the filter is screwed on, and then all the cocks are closed except that on the bent tube. Simultaneously the cock of the filter is opened in order that air may pass through the filter *g* and the tube *h* into the cylinder. The latter cools down as the air enters and the steam is gradually turned off. In short, the cooling is effected by the current of air, which mixed with the steam escapes through the bent tube *c*. So long as a current of steam is seen to escape, the vessel of water *d* is not required; this is only required as an indicator at a later period. If the steam were shut off suddenly, there would be a danger of the filter not admitting a sufficient volume of air to prevent a diminution of the pressure due to cooling, and the result would be either that impure air would be drawn into the cylinder, or the latter might collapse from the external pressure of the atmosphere. Under the conditions mentioned and at the ordinary temperature of the fermenting cellar, the cooling takes about two hours.

With regard to the small vessels of water *d* and *o* at the bottom of the bent tubes, it may be stated once for all that their only object is to indicate the direction of the air current, whether outward or inward.

OPERATION OF THE APPARATUS.

The wort cylinder and its two pipes *s u* and *k* are sterilized in the same manner, but the process of cooling is here omitted. When the steaming is nearly finished, the cock of the air-filter is opened and the wort is admitted. The wort employed is the ordinary hopped lager beer wort, which has been sterilized by boiling in the copper, and is run as hot as possible through the pipe *u* and the cock *s* into the cylinder. Shortly before the steaming is finished the pumping of the boiling wort on to the cooler is commenced, and ten minutes later the cock *s* is opened. The wort is allowed to run into the cylinder until it reaches the upper cock *q*, and the cock *s* is then closed. It is advisable to place a small bucket under the cock *q* to catch the wort which runs out, and when this occurs the cylinder is known to contain the desired volume of wort. The hot steam and air escape partly through *q*

and partly through the bent tube *n*. It is advisable to run off the first small quantity of wort which enters the cylinder by means of the cock *r*, as it is mixed with water from condensed steam, which gives it a disagreeable taste. When the desired quantity of wort is in the cylinder the cocks *q* and *s* are closed. Air, sterilized by passing through the filter, is now forced through the hot wort for an hour before the cooling is commenced, and the aeration is also continued during the process of cooling. Generally, a pressure of from 1 to 2 atmospheres in the air-holder suffices. It is merely necessary that the sterile air in the cylinder should always exert a slight pressure in excess of the atmospheric pressure, and thus prevent any impure air being drawn in, and ensure the full amount of oxygen being taken up by the wort. It is evident that the operator must not forget to first open the cock *n*. If this is not done, there is a risk of injuring the apparatus.

As soon as the wort is ready for cooling, the perforated ring *p* is connected with a water tap and the sprinkler allowed to play against the sides of the cylinder until the temperature of the wort is reduced to about 50° F. (8° R.). In an ordinary fermenting cellar this takes about an hour; the further cooling must be effected by means of iced water. The air is passed through the liquid continuously, and in escaping through the bent tube carries some of the wort with it; the rousing of the wort produces a good deal of foam, but this never gives rise to contamination. The aeration must not, however, be very vigorous or there may be too great a loss of wort. It is only when the wort has cooled to about 52° F. (9° R.) that the foam comes through the tube; this is rendered less troublesome by introducing warm water into the vessel *o*. The wort, now ready for undergoing fermentation, is run through the pipe *k* into the fermenting cylinder.

In order to avoid rousing the wort by the aeration whilst it is passing into the fermenting cylinder, the filter may be connected with a forked tube, one limb of which is a continuation of the air-tube mentioned above, whilst the other only just passes through the top of the cylinder without coming into contact with the liquid. These two limbs must be so arranged that either can be opened or closed by a cock. The air admitted whilst the wort is being run off has, of course, to pass through the last-mentioned limb. This arrangement is not, however, essential. If it is thought desirable that the wort should deposit its sedi-

ment, an hour can be allowed for this to settle. To guard against impure air being drawn in, the filter must not be completely closed, the current of air being merely checked. There is, however, no objection to the sediment remaining in the wort, which may therefore be transferred to the fermenting cylinder as soon as it is cooled. By this time a very considerable sediment will have formed, and as the mouth of the pipe *k* is at a moderate height above the bottom of the wort cylinder, only a small portion of the sediment is carried through.

The wort at first introduced should not reach above the small tube *j*, through which the yeast is introduced. The yeast is previously collected in large two-necked glass flasks or tin cans, and in the transferring operation a spirit lamp may be made use of if a gas flame is not at hand.

The stirring apparatus is now set in motion and the yeast well mixed with the wort. As soon as this is done the remainder of the wort is added until its level rises to the upper mark on the glass tube *f*, the volume then measuring about 1½ barrels. The column of liquid in this tube is forced by the pressure of the air passing through the filter into the cylinder, the cock on the upper horizontal tube *e* being closed, and the cock on the lower tube *h* opened. When it is not desired to continue the aeration during the fermentation, the latter cock is, of course, also closed, but only after the cock above the filter has been closed.

After about ten days the desired portion of the newly formed yeast can be drawn off. It is here assumed that the cylinder has been exposed to the ordinary temperature of the fermenting cellar; if the temperature has been higher, the yeast will naturally be ready for removal in a shorter time. The beer is run off at the cock *l*, and when froth appears this is closed. Some wort from the wort cylinder—which by this time has been recharged with wort for a new fermentation—is now passed in until the level rises to the second mark from the bottom on the glass tube *f*. The yeast is now well stirred up by means of the stirring apparatus, and the mixture of yeast and wort is drawn off into a perfectly clean vessel (cleansed with hot water and then steamed). When the level of the liquid has sunk to the lowest mark on the glass tube, the cock is closed and wort again run in to the second mark. The yeast is again stirred up and drawn off to the lowest mark; the amount withdrawn now

[redacted]

measures about 13 gals. The portion remaining behind is sufficient to start a new growth.

It is advisable to have two marks in the vessel into which the yeast is drawn off, one indicating 6½ gals., and the other 13 gals. Great accuracy is not required in these measurements.

The yeast obtained is sufficient to pitch 8 barrels of wort, and a new fermentation is started as soon as possible in an ordinary and well-cleaned fermenting vessel. If this cannot be done at once, the vessel containing the yeast must be covered over and set aside in a cool and clean place.

Whilst the wort and the beer are being drawn off from the two cylinders, care must naturally be taken that sufficient air is continuously passing through the filters. Otherwise the liquids will not run freely and air will be drawn in from without. As soon as the yeast has been withdrawn from the fermenting cylinder, wort is run in until it reaches the top mark on the glass tube; the contents of the cylinder are mixed by means of the stirrer, and the new growth then commences.

OTHER PURE YEAST APPARATUS.

Other pure yeast apparatuses were constructed by Bergh and Joergensen, Brown and Morris, Elion, Kokosinsky, van Laer, P. Lindner, Wichmann, Wahl and Henius, and others. Nearly all of those apparatus showed only slight modifications of the original Hansen apparatus.

Joergensen was the first to construct an apparatus consisting of a small pitching cylinder and a larger one to be used as a sterilizer and fermenter. The Lindner and Wichmann apparatus were made on the same lines, and so was the Wahl and Henius apparatus.

WAHL AND HENIUS' APPARATUS.

This apparatus is composed of a fermenting cylinder and sterilizer of a capacity of 48 gallons, and pitching cylinders and yeast reservoir of a capacity of 8 gallons.

In the illustration A is the fermenting cylinder; C, the wort conduit with two valves (*a*, *b*); D, steam connection; E, vent-pipe for the beer; F, glass tube, which is connected with the cylinder by H and I (inside of the cylinder the pipe I terminates *in a ring-shaped* perforated tube); G, air-filter (connected with *the air-pump)*; M, doubly bent pipe; K, agitator; L, thermome-

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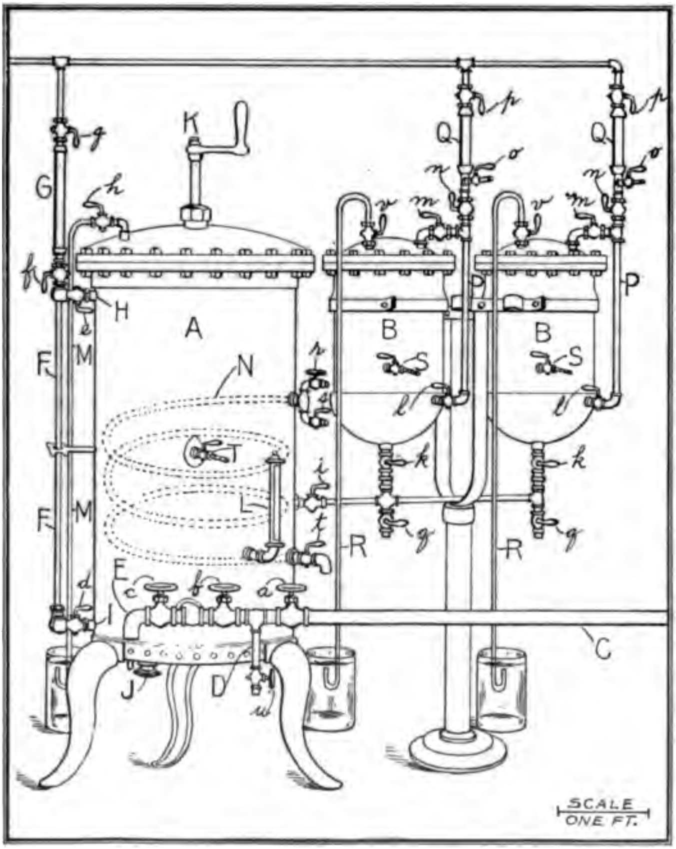
ter; a connection between the fermenting cylinder and the pitching cylinder or starter B; P, glass tube (connected with the cylinder in the same way as F); Q, air-filter; R terminates like



Wahl and Henius Pure Yeast Apparatus.

M in a doubly bent pipe; S, small pipe with rubber tube and glass stopper.

The *fermenting* cylinder A contains a coil through which either

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steam, water or brine can be made to circulate, and has at its bottom an outlet pipe with valve and cap for the yeast.

The apparatus, having been tested for tightness by means of water or steam, is sterilized in the same manner as the Hansen apparatus, the steam entering through D into A, and through N into B, which is sterilized first. When sterilization is over *a* is opened, and the wort conduit thoroughly sterilized with steam before the wort is allowed to enter it. The boiling hot wort now runs into the cylinder, and when the latter is three-fourths filled, *a*, *b* and *e* are closed, and the air allowed to enter the cylinder through *d*. After a few minutes the water (or brine) is sent through the coil, and the wort cooled, care being taken that air is passing through it all the time.

Part of the cooled wort is forced under air-pressure up into B, the pure culture added through S and thoroughly mixed by forcing the air in through *l*. According to the temperature of the wort and the room, B will start to ferment in a day or two, whereupon it is filled up with wort from A. A few days later, when B is in full fermentation again, it is stirred up (with air through *l*), and while air still is entering through *l*, and R is closed, is run down into A and mixed carefully with the wort remaining in that vessel. Part of this mixture is forced back into B and now both are allowed to ferment.

When the fermentation is over the beer in A is removed through E—the air entering through *c*—and, *c* having been closed, the yeast is stirred up by the stirrer K and air that passes through *d*. Now the total yeast is taken out through the bottom opening, the wort conduit C is again sterilized, and the hot wort run into the cylinder to be cooled. This accomplished, the yeast in B is stirred up, air being admitted through *l*, and let down into A, mixed with the sterilized wort, part of which is then forced back into B, and both left to ferment as above. In this manner the apparatus may be kept in continuous operation.

The principal advantages of this apparatus are: It occupies little space, is not very expensive, and yields comparatively a larger amount of pure yeast.

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MALTHOUSE OUTFIT.

TRANSFER OF GRAIN.

The machinery used in transferring or conveying the different grains in the storage elevators or barley and malt in the malthouse and brewery is practically the same in construction and operation.

The grain, etc., is unloaded from the wagon or railroad car by gravity, that is, it is dumped or shoveled into a chute delivering to the "boot" of the elevator or to the conveyor.

A power shovel is often used when unloading cars. This consists of a wide shovel or scoop, propelled or drawn forward by means of a rope attached to, or running over, a power windlass or shaft. This windlass is supplied with a friction wheel, or clutch, to allow the alternate winding and unwinding of the rope, whereby the shovel is drawn forward or the rope unwound so as to allow the shovel to be moved backward for the next operation. Corners and angles between the windlass and shovel are overcome by having the rope pass over swivel pulleys or blocks and tackles, enabling the shovel to be operated at various points surrounding the windlass.

These power shovels are now in general use in floor malthouses to transfer the barley or green malt from any part of the floors to the openings through which the malt falls into the elevator for further transfer.

This shovel has the advantage over the old method of loading the malt upon a truck or wheelbarrow, wherein the malt is carted to the opening, that the shovel is much more rapid in operation, and crushing of the malt berries by the wheels of the truck is practically avoided. (For illustration of power shovel *see next page.)*

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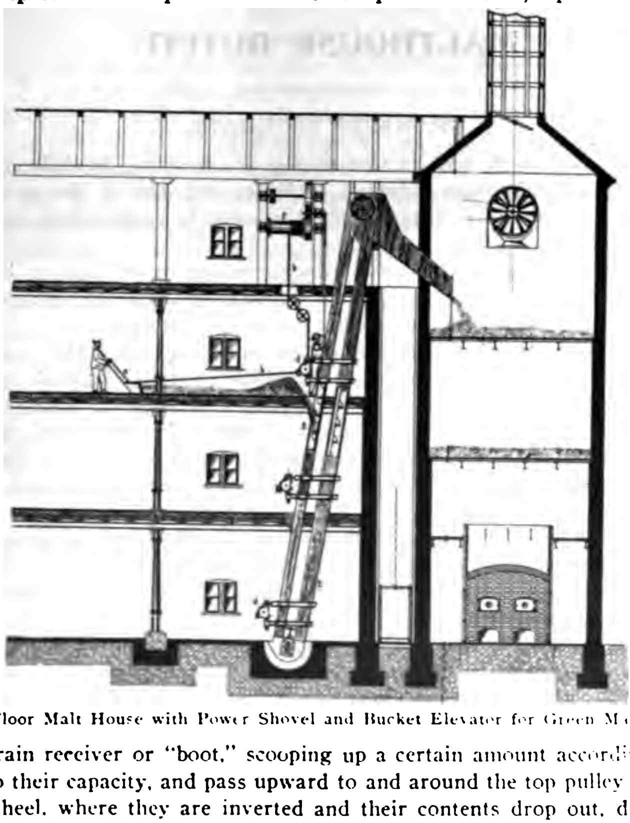
ELEVATORS AND CONVEYORS.

The ordinary appliance for elevating grain, barley, malt, etc., in the brewery, is the bucket elevator. This consists of a number of steel, iron or wooden buckets, attached at equal distances on an endless chain or belt. The buckets, while turning around a pulley or sprocket wheel placed at the lowest point of travel, dip into the



Floor Malt House with Power Shovel and Bucket Elevator for Green Malt

grain receiver or "boot," scooping up a certain amount according to their capacity, and pass upward to and around the top pulley or wheel, where they are inverted and their contents drop out, discharging into a bin or hopper, or being conveyed further, as may be desired.

The conveyor is an appliance used to move and deliver grain

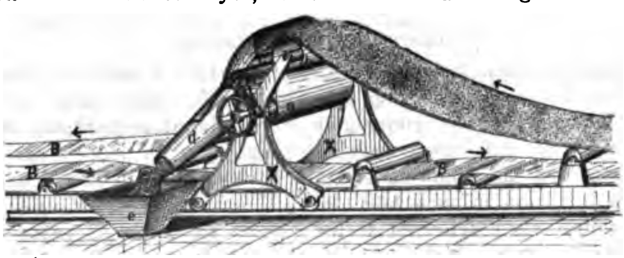
in a horizontal direction. It consists of a wooden trough or box sometimes lined with iron or made entirely of iron in which is placed a closely-fitting spiral iron propeller screw. This screw, in revolving around its axis, pushes the grain with its blades in the direction of the spiral movement.

SIZES AND CAPACITIES OF CONVEYORS.

The following data are furnished by a leading maker, and represent average dimensions:

Outside diameter in inches.	Standard lengths.	Maximum capacity per hour—bushels.	Revolutions per minute.
3 in.	8 ft.	100	100
4 in.	8 ft.	150	100
6 in.	10 ft.	400	150
8 in.	10 ft.	800	150
9 in.	10 ft.	1,000	150
10 in.	10 ft.	1,400	180
12 in.	12 ft.	2,500	180
14 in	12 ft.	3,500	180
16 in.	12 ft.	5,500	180
18 in.	12 ft.	6,000	180

Another conveyor for transferring grain in a horizontal direction is the belt conveyor, which has the advantage over the



Belt Conveyor.

spiral conveyor that grain can be conveyed for long distances, and that during transit the berries cannot be broken, as may happen in a loosely-fitting spiral conveyor. This device also requires less power since the friction of the grain against the blades of the spiral conveyor or conveyor trough is eliminated.

This belt conveyor consists of and is operated as follow

(see illustration): An endless belt *B* runs over two pulleys at either side (not shown in drawing), one of which is the driver, and is supported along its route by a series of pulleys or rollers. The grain falls upon the belt at one side, and is conveyed along until the belt runs over pulley *b*, when the belt suddenly descends while the grain continues in the same direction and falls into spout *c d*, delivering into hopper *e*. The carriage *X* is movable forward and backward by means of rollers running upon rails extending the whole length of the conveyor, so that the grain can be delivered to any number of hoppers *e* placed along the conveyor, which hoppers deliver to bins underneath. The grain can again be divided so as to deliver into two bins by means of the double spouts shown on page 581. Here the grain, falling into *a*, can be delivered through *d* or *e* by pulling on the cords connecting the lever at the top, whereby the one spout is closed and the other simultaneously opened by means of the slides *l* and *c*.

GRAIN AERATORS OR COOLERS.

Should grain become heated while stored in a bin, many grain storage elevators are so arranged that the grain can be äerated or cooled. This is done in a very simple manner by running the grain out of the bottom of the bin into a bucket elevator and discharging it back into the bin at the top.

GRAIN AND BARLEY DRYERS.

Should grain contain too much moisture a device is sometimes installed for drying it. This consists of a series of inclined endless belts, running in boxes placed in a zigzag position above each other, each receiving warm air from a heating device and fan. The moist grain is elevated or delivered to the top belt, and in turn falls on each succeeding lower one. If not dry when delivered at the bottom the grain is again run through, after which it passes through a cooling device to be cooled to storage temperatures.

This device can also be used to dry skimmed or float barley from the steep tanks in the malthouse.

GRAIN MEASURES.

All grain, malt, etc., is bought and sold by the bushel, and the number of bushels in a lot is calculated by weight. When grain is shipped or received in cars or wagons these are weighed with

and without the load, the difference being the total weight of the grain. This is then divided by the bushel weight, determined by a special balance for that purpose, which gives the number of bushels in the load of grain. Most grain storage elevators are supplied with a large scale hopper or bin wherein the grain can be again weighed while in the elevator, either after receipt, or before delivery.

AUTOMATIC MALT WEIGHING SCALES.

Automatic scales are sometimes used and consist of a box arranged in such a manner upon a scale that a certain weight of malt entering at the top forces it down, shutting off the supply and opening the bottom discharge valve. As soon as the box is empty it rises by its decreased weight to its original position, closing the bottom and again opening the top. This operation is continuous. The box is generally arranged to operate with a charge of one or more bushels of 34 pounds each. The amount discharged by each operation is registered on a dial. No attention is required except to start the machine and to stop it when the dial indicates the amount wanted.

This apparatus is not strictly accurate, as the moving parts are numerous and often stick together.

GRAIN AND MALT CLEANERS.

As grain, barley, malt, etc., contain substances that are undesirable, such as chips of wood, foreign seeds, small stones, malt sprouts, etc., it is necessary to clean them before they can be used. Malt is now almost universally cleaned by the maltster before delivery to the brewer.

BARLEY CLEANERS.

Grain is cleaned by the following methods:

1. Forced draught;
2. Sifting or screening;
3. Gravity cleaners.

Forced Draught. A current of air is forced through the grain while it is being fed in an even, thin sheet. The lighter particles such as dust, rootlets, etc., are carried away and the heavier berry falls into a receptacle below.

Sifting or Screening. The grain is passed through and over a series of screens of different size of mesh by an oscillating motion of the screens. In the first series of screens the meshes are

larger than the size of the berry, allowing the berry to fall through and retaining the larger particles. In the second series the meshes are somewhat smaller, retaining the berry and dropping the smaller particles, such as seeds, broken corns, etc. Some constructions have a revolving cylinder instead of oscillating flat sieves. The advantage claimed for the cylinder is that a small berry becoming wedged into the sieve will fall out when it reaches the top position and not clog the sieve.

In some styles of grain cleaners the arrangement is a combination of the draught and sifting methods.

These are now extensively used for both grain and malt. For the latter a somewhat different construction of sieve mesh is used on account of the malt sprouts.

In the grain cleaner the grain first undergoes the action of a fan where light substances are blown away by the air, then over a scalping screen, that is, a screen with meshes larger than the berry, where the larger, heavy substances are retained. It then passes over a screen with meshes smaller than the grain where the smaller particles drop through, and is finally again subjected to the action of the fan to remove particles not at first removed, or that may have become separated by friction while running over the screens.

Another style of barley cleaner consists of a machine having at the top a perforated circular conveyor bottom which contains a spiral conveyor with brushes attached, which distributes the grain over the whole width of the machine, and discharges at the end all substances larger than the perforation. The grain falls into a hopper with automatic valve the whole width of the machine, which regulates the grain when it falls on a division board dividing the grain into two parts. Each part passes the suction chambers separately, whereby all the light substances are removed. The grain then falls on the shoe of the shakers and grader screens, where the grain is spread very thin so that every berry has access to the surface of the shaker screens, of which there are two sizes, fine and coarse, in order to grade the barley.

Through the fine screens all small barley, also broken kernels, cockle, peas, seeds, etc., pass into the cockle reels or cylinders, which separate the small barley from all broken kernels, seeds, etc. Over the fine screens passes the large barley to the second or coarse screens, which will only allow clean, large barley to

pass through into the discharge spouts, while the larger substances like oats, corn, etc., are cast off into the screenings pile.

In another style of combined cleaner the barley first drops on a screen, where sticks, straws and stones, or other foreign substances are taken out. The screen is very wide, so as to allow the barley to spread out into a thin sheet, and to give the berries an opportunity to pass through the perforations and allow none to tail over. After passing through the screen the barley falls into hoppers, which conduct it into the case. The grain then falls upon a rapidly revolving cylinder head, from which it is distributed evenly around in the space between the beaters and the case. The beaters throw the barley into oblong depressions in the case, whence they rebound to the beaters, and in being thrown back and forth between the beaters and the case, the barley is thoroughly scoured and clipped. All the impurities that are loosened are immediately drawn through the slotted openings to the fan, thus not allowing any of the dirt to be rubbed into the crease of the kernel, from which it cannot be removed. After the grain leaves the case it falls into a suction spout and meets a strong current of air which divests it of remaining impurities before it leaves the machine.

MALT CLEANERS.

One style of malt cleaner operates as follows:

The malt is drawn from a garner into a hopper to an automatic feed, which is constructed with a regulating valve, and with an oscillating valve operated by two levers or arms connected with each side of the shoe, in order to secure a perfect and positive feed at all times. In the hopper is also placed a polisher, which is so constructed that it will remove the sprouts, and, while brightening it up, will not break or injure the malt. As most malt contains more or less metal, such as iron, wire and nails, there is placed in the hopper a heavy bank of magnets to remove them. The malt is fed in a thin, even sheet into the first suction leg, where the dust and light impurities are carried by a perfectly controlled air current to a dust room. The greater part of the sprouts are at the same time deposited in the first separating tip. Both separating tips are provided with a conveyor that carries the sprouts out of, and discharges them on either side of, the machine, as may be most convenient for their

removal. From here the malt drops and is spread evenly over the whole width of the upper or scalping screen, which throws off any coarse foreign matter, such as straws, sticks, headings, etc. The malt next passes over a malt screen the entire length of the shoe. Under this is a fine screen, which removes cockle, sand, small seeds, etc. From here it passes into the last suction leg, in which a final separation is made of any impurities that may remain, the malt dropping out of the bottom of the leg in a cleaned condition, while the impurities are drawn into the second tip and removed by the conveyor. The sieves of this machine are all adjustable in the shoe, so as to be changed to finer or coarser ones, while the machine is running. In order to keep the bottom screen from clogging, this machine is supplied with an automatic brush, which travels underneath the bottom screens to keep them clean. The fan-shaft is extended, so that it can be driven from either side of the machine. The two suction legs are the full width of the sieves in order to secure perfect separation. There are two fans in this machine, one on each side of the air trunk for securing a free passage of air at any point and also avoiding sharp currents. This air trunk is so arranged with valves that any desired air current can be obtained at any point of the suction legs where it may be desired.

Gravity Cleaners. These consist of a tall, upright spout or box inside of which are placed a series of steel pins or wires having different distances between them and the whole arranged in rows with one end of the wires free, similar in construction to an ordinary hair comb. These wire combs are placed in the box in an alternate or zigzag position, at right angles to each other, the end of one almost touching the other; in fact, they occupy the position that the steps of a staircase would occupy if they stood on end upright. The grain is fed at the top and falls on the first "comb," thence rebounds to the second and so on to the last. All particles smaller than the berry fall or pass through the wires or "teeth" and are discharged into separate receptacles at either side, while the grain or malt berries fall into another. An advantage possessed by this system of wire teeth is that the grain in striking them causes them to vibrate and dislodge any berry that might have a tendency to clog. These gravity cleaners require no power and can therefore be placed wherever convenient.

In some malthouses the grain is passed through a gravity cleaner, after being cleaned with one of the above mechanical devices, as an extra safeguard.

MALT STORAGE.

The proper storage of barley and malt is a matter of considerable importance, and is usually done in square bins like those described for malt in the brewhouse (which see). Of late, however, a new form of storage receptacle has come into use which possesses features that will gradually enforce its universal installation. This is the steel tank bin.

These bins are constructed to hold many carloads of grain or malt. They possess advantages in the fact that malt or grain can be stored in them without absorbing much moisture; that it is easy to banish the objectionable weevils and other insects which cannot find their way through the steel plates of the tank; or if present are easily removed when the tank is empty and cannot infect subsequent contents; that the risk from fire is lessened to a minimum and consequently a great saving in insurance rates is effected.

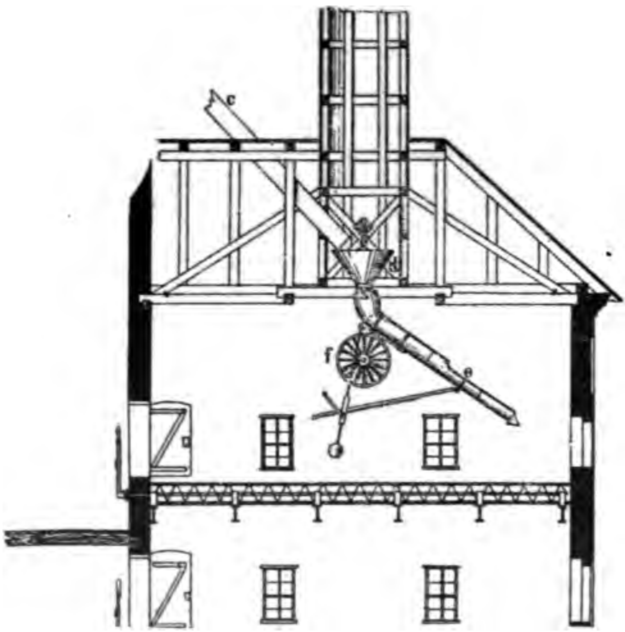
BARLEY WASHING MACHINES.

The washing of the barley previous to entering the steep tank is usually accomplished in one of three manners. One method employs an injector-shaped vessel, where the grain and water are simultaneously allowed to enter, being there thoroughly mixed and the grain washed, whereupon both pass over a sieve, where the grain is intercepted and transferred to the steep tank. The second method proceeds in a closed vessel having an agitator, wherein the grain and water are stirred together and the barley thus washed. The third way is to pass water through the conveyor while the barley is being moved.

STEEP TANKS.

The steep tanks, in which the barley is soaked or steeped, consist now almost universally of cylindrical iron hoppers, with conical bottoms. Attached to the point of the cone is a steep tank valve, which is usually supplied with two opening devices, one for draining off the water, and another for discharging the barley. Some steep tanks are supplied with an aerating device for injecting air into the steeping grain.

Other steep tanks consist of two tanks placed one over the other, the grain being partly steeped in the upper one before dropping into the lower. When there is more than one steep tank they are placed in rows or tiers, and above them runs a spiral conveyor having an opening over each tank, so that in order to drop the grain into any tank all that is necessary is to open the corresponding slide in the conveyor. The tanks are



Revolving Funnel Green Malt Distributor.

also supplied with overflow water pipes for carrying off the float barley and chaff (skimmings).

When the barley or grain is properly steeped it passes either to the growing floors, or into pneumatic drums, etc.

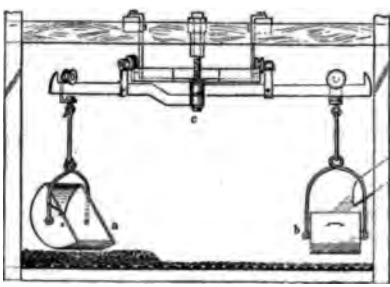
Several devices for turning the malt on the growing floors by machinery have been invented and tried, but did not meet with any general introduction, since they were complicated in detail and often got out of order, causing frequent delays.

FLOOR MALT HOUSE.

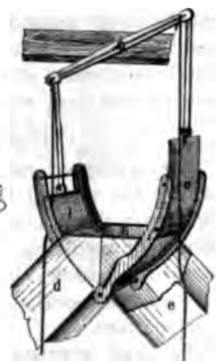
Floor malting is very simple, as far as mechanical equipment is concerned, and requires practically no machinery except the power shovel described above.

The malthouse has different numbers of floors, consisting of different body construction, but nearly all finished with a top coating of cement. The floors have a slight pitch to the sewer pipe to ensure drainage when washed.

The barley is elevated into the steep tanks which are placed on the top floor of the malthouse, from which it falls upon the growing floors below.



Green Malt Distributing Shovel.



Grain Spouts.

The green malt is usually elevated by a bucket elevator to the kiln, and is there distributed by one of three appliances. The one now most commonly in use is a revolving or movable spout (shown in illustration). The malt is dropped by the elevator into the hopper top, and by moving the spout the malt falls to different parts of the kiln, where it is spread out by hand. To the spout are attached two rods in such a manner that they form a triangle with the spout. To the lower or horizontal rod a sliding weight is attached, by moving of which the slant of the spout can be changed. Another style is the movable buckets (see illustration). The green malt falls into one bucket which is then pushed to where wanted and dumped. Another style is the ordinary spiral conveyor, which runs across the kiln lengthwise and has openings at different distances apart at its bottom. By open-

ing the different slides the green malt can be dropped where wanted in heaps and likewise spread by hand.

The construction of the kilns is practically the same as those used for drum malt described below.

MECHANICAL MALTING DEVICES.

Of late years quite a number of mechanical devices for replacing the old-style growing floors have been coming into use and are rapidly supplanting them. The advantages are principally as follows: Smaller buildings and less space to produce a certain output; continuous operation both summer and winter; more regularity in the growing process, etc.; reduced capital invested; less exposure of the growing grain to outside atmospheric influences and consequent lessening of danger of mould, etc.; malt is not crushed by the workmen or shovel in turning; and, last, not least, reduced cost of labor.

PNEUMATIC FLOOR OR BOX MALTING.

This system of malting employs a box-shaped receptacle for holding the steeped barley during the growing period. Traveling across this receptacle lengthwise is a carriage supporting a number of revolving spiral propellers for the purpose of aerating the growing barley by lifting or turning. This carriage travels from end to end automatically, being propelled by wire rope transmission.

The floor consists of perforated or slotted metal, through which the properly attemperated air passes. This air first passes through the attemperators, consisting of perforated zinc plates, over which water is continuously trickling, effecting a moistening of the air to the saturation point, and, at the same time, purifying it and equalizing the temperature. In cold weather the air first passes through a system of steam coils to be warmed, while in warm weather the air is cooled by the evaporation taking place in the moisteners. This air can thus be kept at a uniform temperature all the year round.

The moistening of the growing barley can be accomplished by passing water through the shafts of the screw propellers, which are provided with sprinklers, so that as they travel through the grain the same is equally moistened. The growing boxes are also made double, one above the other, so that the process can be carried out in a more economical manner as to ventilation, etc.

Another system of pneumatic box malting is very much similar in general details to the one above described, the main difference being in the shape of the receptacle containing the growing barley. Here this box or receptacle is round, having at its edge and near the top a circular cogwheel or ring attached, with the cogs pointing inward. The stirring and turning device is attached to an horizontal shaft revolving on an upright central shaft as an axle by means of a cogwheel at its end fitting into this circular cog ring, in fact, similar in construction to a one-armed mash tun stirrer. The advantage claimed in this circular device is that each portion of the growing barley is turned at regular intervals at every revolution of the shovels, while in the first system where the turners travel from end to end and back again the middle portion is the only one turned at regular intervals, while those at the ends are turned twice in quick succession and then left undisturbed for some time.

This round system, however, has found only limited installation, while the square system is in extensive use and has, by long experience given good results.

DRUM MALTING.

The cooled or heated and moistened air used in pneumatic floor systems circulates through the whole space in the rooms, as well as through the barley receptacles, consequently a very large volume of this treated air must be furnished. This quantity of air is considerably lessened by the employment of drum-shaped receptacles for containing the growing barley.

Drum systems differ from each other mainly in the construction of details and methods of using the prepared air. They are all, however, similar in the following points, namely: At every revolution of the drum every portion of barley contained undergoes the same change that it did in previous revolutions, hence, there is uniformity in turning; the circulation of the prepared air passing through the growing barley can be well regulated; there is little barley exposed to the air in the unfilled portion of the drum, consequently the grain does not dry out much; and there are no shovels or stirrers to injure the barley berries.

In the construction of the drums there is also this similarity in all systems: That they consist of two concentric perforated iron cylinders, a smaller one placed inside a larger one, the barley being placed in the space between the two cylinders, but both having

the same heads and revolving on the same central shaft, the whole being supported by four friction wheels or pulleys and revolved by means of a worm gear. The drums are also supplied with sliding doors so as to allow examination of the contents during the process, and also for filling and emptying.

One construction of malting drum now in use has two inlets for air, one at one end of the central cylinder for injection of moistened air, and one at the other end for dry air. The moist air in this system is injected upon the growing barley with considerable force, thereby loosening the barley and causing better turning while the drum revolves. Two thermometers and two wheel throttles are inserted, one at each end of the inner cylinder, in order to allow the observation of the temperature of the injected air and to regulate its pressure.

Another system of malting drum in extensive use passes the air through the growing barley in practically the opposite manner described in the foregoing. The air passes from around the outside larger perforated cylinder inward, and finds its exit through the inner perforated cylinder, both being encased by a third not perforated cylinder. Furthermore, the air here is not forced in by compression, but is sucked or drawn through by an exhaust fan. The air for purification and attemperation is drawn through a tower or cylinder filled with coke, at the top of which water is sprayed under pressure, being cold in summer and warm in winter, in order to preserve an equal temperature of the air. This drum also has a thermometer and valve for observing the temperature and regulating the draft.

Another form of drum has the inner cylinder tapering or cone-shaped, with the small end near the suction end of the drum. The advantage claimed here is that at the smaller end of the inner cone, which is surrounded with more grain, the suction is greater, and this greater suction, passing through this larger body of grain, is proportionally reduced, consequently the air passes with equal force through every part of the drum, causing a more even growth.

In still another system the drum consists of two concentric cylinders, but allows the inner one to revolve independently of the outer or larger one, so that the two cylinders can be given different speed. By these two different speeds it is claimed that the growing barley is more thoroughly turned.

MALT KILNS.

After the growing barley, now called green malt, has reached the desired stage of growth, the next operation necessary is quickly to check this growth. This is done by drying the moist malt upon the kiln. Here it is not only deprived of its moisture, but also receives certain new characteristics, the latter depending upon the amount of moisture contained at certain temperatures. The temperatures in the kiln therefore must be easily regulated. The green malt, in discharging from the drums, falls into a horizontal conveyor, which discharges it by means of a bucket elevator to the kilns where it is distributed as above described.

Kiln Floors. The kiln consists of perforated floors below which are furnaces supplying the heat for drying.

In order to save fuel, building space and labor, the kiln floors are placed one over the other, usually two in number, although occasionally, especially in large plants, there are three such floors. The dryer malt is placed upon the lower and the more moist upon the top floor and the heat applied from below, so that the greater amount of moisture is nearest the exhaust and does not pass through the dryer malt.

Dumping Floors. The kiln floors are constructed of perforated or slotted metal and in order to allow the malt to drop upon the floor beneath are made to open partly and are then called "dumping" floors. These consist of a number of strips of perforated metal which, when all laid horizontally, form an even floor, but, each being centrally pivoted at the smaller end, can be tilted or given a quarter turn so that each strip assumes a vertical position and any malt resting on it is dropped or "dumped" on the floor below. The pivot or bearing on one end of these strips usually extends through the wall and is supplied at the outside with a lever handle for the purpose of turning and closing from the outside.

A mechanical *device for turning the malt* upon the same kiln has lately been installed. This consists of a series of short conveyor screws each attached to a vertical shaft, and these shafts in turn supported by and revolving in an overhead beam or traveling crane running from end to end of the kiln. As the revolving screws travel through the malt they lift the lower layers and allow the upper to fall in their place, thus turning the malt evenly.

The furnaces for furnishing the heat to the kilns are usually open at both ends and are supplied with draft regulating air shafts. The fuel is usually anthracite pea coal or coke, and special care should be taken to add little fuel often in order to reduce the smoke production to a minimum.

COMBINED DRUM AND KILN.

As the handling of the green malt from the drum to and upon the kiln necessitates considerable labor, and the installation of the kilns considerable capital, one system of malting now in use does away with the extra kilns by also using the drums as kilns.

The manipulation of these drums differs little during the growing period from those used for germination only. But at the time growth is completed, the green malt, instead of being taken out, remains in the drum and the cool, moist air used in the growing period is replaced by dry, hot air and the drum is used as a kiln. In this system the drum is in uninterrupted operation from the time it is filled with steeped barley until the latter is taken out as finished malt.

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MALTING OPERATIONS.

GENERAL OUTLINE.

Malting is the process of preparing the grain—commonly barley—for use in the production of beer wort. Broadly, it embraces every manipulation from the moment the crude grain leaves the elevator or storehouse up to the time the finished malt is conveyed to the storage bin or to the hopper to be measured into the crusher mill. In a more confined sense, the term is sometimes applied only to the three operations of steeping, germination and kiln-drying.

IMPORTANCE OF MALT.

Among all the materials, undoubtedly the greatest importance attaches to the malt. It is only in malted grain that we find not only the materials necessary to give substance to the beer, in fact to supply the greater part of the extract, and all the essential ingredients which make up the character of the beer except those which are derived from the hops and the water, but also the enzymes—diastase and peptase—that prepare those ingredients by the inversion of the starch and peptonization of albumen. Unmalted grain may supply starch; malt alone supplies the important albuminoids and the enzymes.

It follows that while it is possible to make beer, using as the starch-yielding basis only barley malt, it is impossible to prepare a beer wort from unmalted cereals only. A certain amount of malt is indispensable to supply the enzymes in sufficient force to invert the starch both of the malt and of the unmalted cereals. The latter are, therefore, properly *malt adjuncts, not substitutes.*

CHARACTER OF BEER DEPENDS ON MALT.

Fulness of body (palate), foam-holding capacity, taste, aroma and color of the beer are largely derived from the malt. The complete dependence of the character of beer upon that of the malt is illustrated by the two extreme types of Bohemian and Munich beers which display the greatest differences of character, although the identical mashing method may be followed and the malt prepared from the same barley, provided only due regard was had in the malting process to the character of beer to be turned out.

PARTS OF THE KERNEL.

The barleycorn consists in the main of the "husk," the "germ" and the "endosperm." The husk is mainly for protection, the germ contains the vital principle endowed with the faculty of growth, under suitable conditions, into the new plant, the endosperm contains the bulk of the nourishment to sustain the germ until, in the natural order of things, the roots are sufficiently developed to draw sustenance from the soil in which the grain is growing.

The germ of the barleycorn develops, during growth, the "acrospire" or "plumula" and the "radicle." The former is that part from which develops the green blade which appears above the ground where barley is planted, and eventually produces the stalk. The radicle sends out a number of shoots that develop into the roots of the plant and are commonly called "rootlets."

In germination, the rootlets protrude at the germ end of the grain, while the acrospire, starting from the same end, grows up toward the other end of the grain, keeping under the husk along the back or solid side of the grain. In the natural process of growth it finally breaks out at the end opposite the rootlets and grows up into the blade.

In malting, it is not allowed to reach this point, growth being checked suddenly by kiln-drying before the acrospire quite reaches the opposite end, experience having demonstrated that the most desirable condition of the endosperm coincides with that degree of development of the acrospire.

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PRINCIPLES OF MALTING.

The nourishment for the germ stored up by nature in the endosperm consists, in the main, of starch, albuminoids and a small amount of mineral substances. It is necessary that this food shall be made soluble and modified, so as to be available by the growing germ. This is done by diastase and peptase, respectively, two enzymes which are developed in the growing malt in proportion to the needs of the germ for increased quantities of food, and their function is to attack the starch and nitrogenous substances, changing them into sugar and amides which, together with phosphate of potash, constitute the three main articles of food on which the growing germ subsists.

The germ cannot obtain its food and grow properly unless it is given a sufficient quantity of water, nor unless the temperature is congenial. Oxygen also is necessary to carry on the life of the germ.

Under proper conditions of life as to amount of moisture, degree of heat and supply of oxygen, then, the germ will take up sugar, amides and mineral substances. The sugar is split up into carbonic acid and water, and jointly with the amides and mineral substances goes to build up the body of the acrospire and radicles, and supply the vital energy of the germs.

SUPPLYING THE MOISTURE.

The required moisture is supplied by steeping, that is, immersing the grain in water to allow it to take up a sufficient amount thereof to start germination. In the progress of growth much water evaporates, and it is always necessary to make up the loss by sprinkling during the more advanced stages of germination.

TEMPERATURE DURING GERMINATION.

Since by the decomposition of the sugar into carbonic acid and moisture, heat is generated, the temperature of the barley heaped on the floor of the malthouse will be increased. The temperature in the heap will rise in proportion to the amount of maltose consumed by the growing germ. The higher the temperature of the heap, therefore, and the greater the size that the radicles and acrospire have attained, the greater will be the amount of maltose split up within a given period, and the thinner must the layer of malt be spread to keep the temperatu

of the heap within the proper bounds. Too high a temperature of the heap favors the development of fungus growths and impairs the uniform growth and character of the malt.

OBJECTS OF GERMINATION.

The immediate objects of germination are:

1. To open up the endosperm, making the same sufficiently porous so that starch and albuminoids will be readily invertible in the mash-tun.
2. To obtain sufficient quantities of diastase and peptase to effect inversion.

These objects must be obtained with a loss of as little substance as possible.

OPENING UP THE ENDOSPERM.

The removal of starch, albuminoids and mineral substances consumed by the growing germ, by solution and inversion, takes place along diminutive canals intersecting the endosperm. These canals are enlarged by the removal of the consumed particles as germination progresses, and the endosperm becomes more and more porous and spongy. At the same time the enzyme "cytase" emanating from the scutellum part of the berry permeates the endosperm, and gradually dissolves the membranes of cellulose in which the starch granules are encased, thus facilitating the solution of the food particles. The modifications which the endosperm undergoes in this process are precisely the ones required to fit it for use in the preparation of beer wort, since the diastase and peptase generated in germination are needed in the mashing process for the inversion of the starch and nitrogenous substances (albumen) of the endosperm.

Thus, while the germs themselves are not wanted in brewing, and the consumption of nourishment by them from the grain materially depletes the endosperm, thereby diminishing the amount of matter available for the preparation of wort, nevertheless, the generation of the enzymes and consequent modification of the contents of the barleycorn are operations absolutely indispensable for the production of beer wort; the endosperm becomes more mellow, that is, more readily permeable by water, which is important for the quick inversion of the starch in the mash-tun, and the nitrogenous substances become modified so that they will be acted upon by the peptase in the mash-tun, yielding the all-important albuminoids necessary to give character to a beer. Unmalted cereals do not yield any desirable albuminoids in the mash-tun.

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Malting, then, consists, in the main, of the operations necessary to bring about these modifications of the endosperm, eventually making the malt so prepared stable, and adding flavor and color by kilning. To this end, germination is induced and fostered, and, at last, interrupted at the critical moment when it has proceeded to a certain degree.

INTERRUPTING GERMINATION.

This is done by expelling the moisture by kiln-drying. Malt should be so dried as to possess, when finished, the desired color, aroma, mellowness and diastatic strength, all of which properties are governed, to a large extent, by the conditions of drying.

The modifications that take place in the dry-kiln depend, in the main, upon the proper adjustment of temperature to the degree of moisture in the malt. This is a very delicate task.

TEMPERATURES IN DRY-KILN—COLOR—AROMA.

Temperature affects the strength of diastase more severely while the malt is moist than after it becomes dry. The more moisture is expelled before the temperatures are raised high in the kiln, the greater will the diastatic power of the malt remain.

With reference to obtaining the color and aroma that may be desired, the relation between moisture and temperature is also of the greatest importance. Under the influence of higher temperatures—above 111° F. (35° R.)—the moisture will tend to liquefy, or gelatinize, the starch, in part, and in that condition the diastase will invert the starch, producing maltose and maltodextrin. The heat increasing, these products of inversion will be caramelized, giving color and aroma. Again the liquefied starch, as well as the inversion products, will fill up the capillary canals, and there settle and be dried, resulting in a malt less mellow and inferior in diastatic and peptonizing power, the latter being affected presumably by the same conditions as the diastatic power.

The less moisture, therefore, a malt contains when those temperatures on the kiln are reached at which the starch gelatinizes and is inverted, the paler will be its color, the less pronounced will be its malt flavor, the less will its mellowness and diastatic power be impaired; while the longer the moisture is in evaporating, the tighter will the husk close around the endosperm, resulting in a malt with higher bushelweight, but of greater resistance toward atmospheric influences, like moisture, *which is absorbed by* malt the more readily in storage, the quicker *the kiln-drying process* has been carried out.

POINTS ABOUT MALTING.

CLEANING, SEPARATING AND WASHING BARLEY.

The barley, as it comes from the elevator, always contains much dust, seeds from other plants, half or injured kernels and kernels of other cereals.

The dust, containing numberless foreign organisms, promotes mould and decomposition.

The foreign seeds may impart to the malt a foreign taste, and the injured kernels also promote the growth of mold.

Moreover, if the size of the kernels is very irregular, then in steeping the smaller kernels would become sufficiently steeped more speedily than the larger ones, which might take hours more to become thoroughly soaked. The result would be irregular growth.

It is necessary, therefore, to clean the barley, separate and grade the kernels according to size, and, if desirable, wash it.

This is done by machines known as barley cleaners and separators, the chief parts of which are described in "Malthouse Outfit." (Pages 575-578.)

STEEPING.

Steeping is the process of soaking the barley with water, and is performed by immersing the grain in the steep tank for a period of time under certain conditions. It aims to impart to the grain sufficient moisture to start and carry on germination and, also, to dissolve from the husk the coloring matter and other extractible substances which otherwise would give the malt a raw taste.

Different varieties of barley will absorb different amounts of water in a given time. The period of steeping depends on:

1. The character of the water, whether soft or hard.
2. The temperature of the water.
3. The character of the barley, whether the hull is thick or thin, whether the endosperm is mealy or glassy, whether the diameter of the kernel is greater or smaller.
4. The age of the barley.

CHARACTER OF STEEP WATER.

There has been much discussion as to the proper character of *the steep water.* Soft water dissolves from the barley too much

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soluble albuminoids and mineral substances which the yeast requires for food. The best water for steeping is a medium hard, pure spring or shallow well water. The temperature of the water should not exceed 55° F. (10° R.), otherwise moldy growth will be encouraged. In winter, the water should be warmed to the proper temperature before it is run into the steeping tanks.

The softer the water, the higher its temperature, the smaller the diameter of the berry, the thinner the husk, the more mealy the barley, the younger the barley—the less time is required for steeping.

Barley should never be oversteeped or be allowed to become sodden, otherwise its vitality may be seriously impaired. Sprinkling on the floor can be resorted to if there is not enough moisture in the grain, but where there is too much, it cannot be removed. It is safer to understeep than the opposite.

Since grain always contains some mold spores which find favorable conditions for growth during the germinating period, and may, under circumstances, have an effect on the flavor of the final product, it may become advisable, when moldy growth is feared, to use some antiseptic to keep them in check, such as bisulphite of lime or other suitable substance, which should be added to the steep water for the first steep of the grain.

SIGNS OF SUFFICIENT STEEPING.

1. When cutting through a grain, the contents should show completely and uniformly wetted, with the exception of a minute speck in the center of the endosperm.
2. When taken by the ends between thumb and index finger, and pressed, the kernel should not prick the skin.
3. The kernel should be elastic enough to be bent over the finger nail without breaking.
4. At the end where the radicle is located the hull should appear to open.
5. Upon biting gently into a kernel, the endosperm should move to both sides without breaking or cracking.
6. A sample of barley taken from the steeping tank should show an increase in weight of about 45 per cent.

Of these indications, Nos. 1 and 6 are the most reliable.

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PERIOD OF STEEPING.

This is a matter in which the individual judgment of the maltster must of necessity be allowed much play. Only approximate hours can be given, as follows:

For Two-Row Barley:

California	50 to 60 hours
Dakota, Montana, Utah	60 to 72 hours

Six-Row Barley:

Iowa, Minnesota or Wisconsin No. 1	48 to 56 hours
Iowa, Minnesota or Wisconsin No. 2	45 to 52 hours
Iowa, Minnesota or Wisconsin No. 3	36 to 48 hours
Canada	45 to 56 hours

CHANGES THAT TAKE PLACE DURING STEEPING.

The barley takes up a large amount of water; the volume of steeped barley is 25 per cent greater than of dry barley, four bushels of dry barley yielding five bushels of steeped. The increase in weight is about 45 per cent, or 100 pounds of dry barley give about 145 pounds of steeped.

A certain amount of various matters, both organic and mineral, is extracted from the barley by the water, the total amount being about 1.5 per cent. Among the substances so dissolved out are: Cane sugar, gum, diastase, coloring matter, phosphoric acid and about one-half of the soluble nitrogenous constitutents.

GERMINATING.

The grain having reached the desired degree of steepage, it is sent to the germinating department.

According to the traditional method, which still remains the most common, germination is conducted on a smooth floor constructed for this purpose, the process being called "flooring," "growing," or "germinating." Of late years some improvements have been introduced in this branch of malting, being based on artificial or forced aeration either on a perforated floor or in revolving drums. Another important distinction is that by the old method the work is almost entirely done by hand, whereas the recent improvements may with much propriety be called *mechanical malting*, most of the work being done by machinery.

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COMMON FLOOR MALTING.

The grain is sent from the steep tank to the germinating floor after the water has been drained off. It was customary, of old, to shovel it out of the steep tank on drays and convey it to the floor. In a modern malthouse the steep tank is provided with a conical hopper bottom, and situated above the malting floor, so that, the trap in the bottom being opened, the grain slides down on the floor in a heap.

The lot of grain so sent to the floor is called a "piece."

The first heap is called a "couch," that name being derived from the practice under the former English law, when the duty was paid on steeped barley, which was measured by the government gauger in an open frame called the couch, designed to hold a certain bulk and provided with a removable end which was taken out as soon as the grain had been gauged, and the malt then moved out on the floor through the open end. Such couches are still commonly used in England, but not in the United States, where the term couch has been applied to the first heap, the practice of malting, however, being derived mainly from German methods.

The couch is set at one end or side of the floor, and the malt gradually worked over toward the opposite end, or side, at which the dry-kiln is situated.

The chief points to be observed in carrying on germination are:

1. To provide sufficient moisture;
2. To maintain suitable temperatures;
3. To aerate the grain (ventilation);
4. To protect the growing grain from deleterious influences.

All these essential conditions should be so observed as to operate upon all individual grains alike, in order to secure a uniform growth. Too high temperatures must be avoided since they promote the development of micro-organisms and facilitate uneven growth.

Growth should not be allowed to proceed too rapidly. The saving of time that might thus be effected is far more than made up for by the fact that an unduly swift development of the acrospire and radicles will not allow of the requisite *mellowing of the endosperm* which is among the chief objects of germi-

nation. Forced growth, therefore, is to be strictly avoided. Excessive temperatures have a forcing influence.

The requisite moisture is provided, in the first place, by steeping. Subsequently, at more advanced stages of development, if the grain gets dry, sprinkling is resorted to. In some floors, and generally in pneumatic malting, moist air is introduced.

Turning the Heap.—Temperature is maintained not only by regulating the warmth of the air in the floor and that of the floor itself, having an eye to the temperature outside, but also by breaking the couch and turning the piece. This is resorted to when the temperature in the heap rises too high. The higher the pieces are set, the less frequently they are turned, the higher the temperature of the surrounding air, the warmer the couch—the quicker will the temperature rise in the heap.

Aeration is provided by suitable ventilation of the whole floor. Turning the heap also serves to aerate the grain by dispelling the carbonic acid generated and bringing the previously covered grains into contact with the air. In pneumatic malting a current of air is forced through the grain by powerful fans.

Protection from deleterious influences, besides those above enumerated, consists mainly in restricting the opportunities for mold to develop chiefly by observing the strictest cleanliness, avoiding crushing of any grains, keeping out injurious gases like coal gas, etc.

GENERAL RULES FOR FLOOR WORK.

The following general rules may be set down for floor work:

Turn the piece regularly and so that the kernels near the surface are brought nearer the center of the new heap, and those that have been nearer the center are brought to the surface or bottom. Each succeeding heap is spread lower than the preceding one to keep down the temperature, because as the germs grow in size, needing more food, more heat is generated.

In turning, the bottom parts of the old heap should become the top parts of the new heap, and the top parts be at the bottom.

The heaps should in all parts be made equally high.

Pure fresh air is essential to proper growth. There should be good ventilation. The temperature of the air admitted should *preferably* not be lower than 55° F. (10° R.).

If there is too much evaporation, if the growing barley becomes *too dry, in* which case the radicles—sprouts—will be seen

to wither, the barley should be sprinkled with water of approximately the same temperature as that of the heaps.

The most scrupulous cleanliness should be observed, the floor should be kept clean by water and applications of bisulphite of lime. Injured or crushed kernels give rise to lactic acid fermentation and mold formation.

Coal gas, illuminating gas, is exceedingly injurious to the growing barley; the floors should not be lighted by gas. Larger quantities of sulphurous acid are also injurious.

As soon as the malt has started to sprout it should be sprinkled and turned, after which the heap is set somewhat higher, and the temperature is allowed to rise to 68° F. (16° R.), when it is broken and spread out thinner. If the heap is sprinkled before the sprouts appear, growth is apt to be checked.

METHODS OF FLOOR WORK.

There are two principal different methods of carrying on the floor work:

Warm Sweat Method.—The temperature of the heaps is allowed to rise high, viz., 77 to 86° F. (20 to 24° R.). The radicles develop rapidly, the acrospire very unevenly. Germination is rapidly completed.

Cold Sweat Method.—The temperature of the heaps is kept low, about 63.5° F. (14° R.). The acrospire develops gradually and more uniformly, but germination takes longer. The cooler a heap is kept, the better is the quality of the malt regarding solubility, diastatic power and aroma.

"Sweat" is the moisture which will appear on the surface of the barleycorns during germination, the vapors passing from the interior of a warm heap and condensing near the surface. The appearance of this "sweat" is a sign of healthy growth.

In England the temperatures are kept quite low on the floor, about 50° to 55° F. (8° to 10° R.); in Germany they range up to about 70° F. (17° R.); in America up to about 77° F. (20° R.).

INDICATIONS OF PROPER GROWTH.

During the growth of the barley a fine fruit-like odor, reminding of cucumbers, should be noticeable. The more mold, the more this odor is covered.

The color of the germ should not change.

The *acrospire should* develop uniformly in all kernels.

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The radicles should never look withered. They should, toward the end, be allowed to grow into one another and mat.

Sweat should appear a few hours after turning a heap, making its appearance the sooner after turning, the higher the temperature rises.

SIGNS OF SUFFICIENT GROWTH.

The acrospire should be developed to ¾ of the length of the kernel ("three-quarters up").

The radicles should be developed to 1½ of the length of the kernel.

Upon the kernel being pressed between the thumb and forefinger, the endosperm should be squeezed out and should have the consistency of mealy flour.

The radicles should cling together firmly so that in lifting a number of kernels between the fingers, they should draw with them six to eight times the number of kernels held.

KILNING.

The malt is called green malt until it has entered upon the drying stage which follows germination.

The proper condition of mellowness having been reached, steps are taken to interrupt growth as promptly as possible. This is done by expelling a large share of the moisture in the malt.

Currently in the United States, this is done by conveying the green malt straight into the kiln. The kiln having almost invariably two floors, the green malt is dumped on the upper floor and there dried slowly to the requisite degree.

In the older beer-producing countries it is quite a common practice to make a distinct operation of preliminary drying. In Germany the malt is frequently air-dried in the so-called "Schwelke" at ordinary temperature before being sent into the kiln. In England it is "withered" by heaping the malt into a thicker piece and leaving it for hours, whereby the temperature is increased, ventilation impeded and growth at least partially checked. This is made necessary by the general use of one-floor kilns in England. Withering may also be accomplished by spreading the germinated malt very thinly upon the floor, thus facilitating the escape of moisture.

American maltsters often turn the malt twice in the last three *or four hours,* so as to ventilate it, reduce the temperature and *check growth.* As a rule, air-drying is considered superfluous in

the United States. Air-dried malt is used in distilleries for the manufacture of whiskies. Green malt contains about 35 to 40 per cent of moisture, air-dried malt about 13 to 15 per cent.

While the malt is on the upper kiln floor, where nothing is sought to be accomplished beyond driving off moisture, the temperature should be kept comparatively low until the moisture has been, for the greatest part, expelled through the agency, mainly, of currents or draughts of air.

The desired degree of dryness being obtained, the malt is dumped on the lower kiln floor. The regulation of temperatures on the lower kiln floors is governed by the desired quality of the final product.

AMERICAN MALTING OPERATIONS.

The description here given follows the practice of some of the large American establishments:

FLOOR MALTING OPERATIONS.

The barley from the bins is loaded on the conveyor and carried automatically to the cleaning machine. The entire cleaning process is automatic, and the refuse carried off by mechanical devices. Foreign seeds go into one bin, and often there is another for broken barleycorns. This offal goes to feed dealers, while the chaff that is collected separately is used in the brewery for fuel or otherwise disposed of.

From the cleaning machine the barley drops into the separator underneath. The different grades, two or three in number, go to the automatic scales, by which the men are enabled to charge the steep tanks with the requisite quantities, turning the barley into a fresh tank as soon as one has been filled to the proper degree. Sometimes the barley is measured into the tank or is gauged by the height in the tank. Hopper scales are frequently used.

Before running in the grain for washing there should be one and one-half to two feet of water in the tank. The tank being properly charged, turn on the water and let it run over at the top. At first, the water should stand one to two feet above the barley when the tank is full. Where there is plenty of water, keep it running, preferably at the bottom, and it will keep the barley stirred up and float the skimmings off at the top. Otherwise, skim them off with a ladle. The skimmings go to a separate bin or trough, and are sold for feed. Keep the water running

three or four hours, but drain it off entirely once a day. Where the water cannot be kept running, change it twice the first day, and once a day thereafter.

For steeping, the grain is kept in the same tank. Temper the water in the tanks before running it on the grain so that it is about 50-55° F. when it reaches the steep tank. Keep the temperature of the room so as to preserve this degree in the tanks as nearly as can be. Steep for about forty-eight hours, modifying for dryness of air, hardness of water, type and condition of barley, etc. When the time is nearly past, sample the grain at short intervals, according to the tests elsewhere described.

The grain being fully steeped, drain the water off at the bottom. Frequently the steep tank has a conical hopper bottom by which the barley is dropped on the malting floor; otherwise it is loaded on trucks and wheeled to the floor. In couching, the head maltster directs the placing of the loads so that on leveling the grain will form a heap eight to ten inches in height, extending along a longitudinal side of the floor and occupying rather more than one-third and less than one-half of the floor space. About every six hours the maltsters turn the barley to enable rapid superficial drying. Keep the temperature in the room between 50° and 60° F., as uniformly as practicable. See to good ventilation all the time. At the expiration of about twelve hours, the barley being dry, the heap is drawn together, that is, the men shovel the grain together and level it at twelve to fourteen inches. Leave it at this height, turning every eight hours, until the rootlets mat well. Use the thermometer freely, pushing it down into the couch. If the temperature approaches 75° F., break down the heap and extend it to a layer of less depth. This repeated breaking down or flooring of the heap gradually extends it over that part of the floor which was originally left free.

When the grain mats strongly, sprinkle with water, either by hose and spraying pipe or by a sprinkling can. If possible, enough water should be given to save another sprinkling. Turn every five or six hours thereafter, breaking down the heap more and more, until the layer is only five or six inches deep and covers almost the whole floor. Growth will take about five days. When the malt is mellow, and the acrospire about three-quarters up, *turn* the malt once or twice in the last three or four hours so as to *ventilate the heap* thoroughly and stop further growth. Most *American barley*, being rather refractory in malting, should not

be turned too much. There are some exceptions, as California barley, which grows even on the shovel. Turning should be delayed until the temperature of the malt imperatively requires it. After clearing the floor of green malt, wash it well with diluted bisulphite, or milk, of lime. Then wash well to remove all traces of the chemicals.

KILNING OPERATIONS.

The malt ready for the drying-kiln, it is conveyed to the elevator at the end of the floor by means of scrapers suspended from the transmission shafting under the ceiling. The scrapers are handled like plows, being set in place and guided by the maltster, while operated by machinery. The receptacles of the elevator are charged by the scrapers, and on reaching the upper floor of the kiln, dump the malt automatically. On the upper kiln floor the men level the malt to an even height. The dry-kiln in the United States commonly has two floors, and is heated by an open fire. Above the upper floor in the dome are drafts to carry off the vapors, and often a suction fan to promote drying. The temperature should be kept at 75-90° F. on the upper floor. Where the suction is such that a powerful draught can be maintained through the malt, there is no need of turning the malt, but it is sufficient to loosen it up once. With a less perfect draught, turn once about three or four hours after loading the kiln. Where ventilation is insufficient, turn after six or eight hours, and again after nine or ten hours.

The upper kiln is loaded about 18 inches high. All temperatures referred to in kilning American malts are read from thermometers, the bulbs of which are immersed in the malt extending about half way between surface of malt and kiln floor or about nine inches from surface. Usually three thermometers are placed, one at each end and one in the center. The charge on a kiln floor is usually 2,500 bushels in the larger malting establishments, or 5,000 on both floors.

The malt, being hand-dry, which takes about twenty-four hours, is dumped on the lower floor, commonly by mechanical dumping floors which turn in sections on an axis and drop the malt below. Spread the malt evenly on the lower floor. The initial temperature here should be 120-130° F., leaving it about that point for twelve hours, more or less, until the malt is absolutely dry. Then raise within one and one-half to two hours to the final temperature and keep at that height for about two hours.

Final temperature for pale malt should be about 145° F., for market beer 165-180°, for high-dried malt for darker beer up to 220° F. The curing stage being over, cover the fires and cool the malt slowly.

Hard coal, being smokeless, is commonly used for fuel. The fireman should see to the maintenance of the proper temperatures by watching his fire and the dampers.

The malt being cooled down, it is shot through traps from the lower kiln floor to the cleaning machine stationed so that the malt drops into it without any assistance. The rootlets or "coombs" are here removed. The clean malt runs into one bin, the roots into another, and there remain until the malt is used for brewing, or the rootlets sold for feed.

KILNING AMERICAN MALT FOR PALE BEER.

Time of kilning, 48 hours.

After loading, the temperature is raised during the next ten hours to 90° F. (25-26° R.), during the next four hours to 120° F. (39° R.), and kept at this temperature for ten hours. Now the malt is dumped on the lower floor, where the temperature is raised during the next four hours to 130° F. (43-44° R.); during the next twelve hours to 150° F. (52-53° R.); during the next three hours to 180° F. (65-66° R.), and held at this temperature during three hours when the malt is removed from the lower kiln to the bin, and the lower kiln receives a new charge from the upper kiln, and the upper kiln is reloaded, the time of unloading and recharging the kilns being about two hours.

KILNING AMERICAN MALT FOR EXTRA PALE BEER.

Time of kilning, 48 hours.

On the upper floor the malt is treated as for pale beer. The malt reaches the lower kiln with a temperature of 120° F. (39° R.), which is gradually raised during the next four hours to 125° F. (41-42° R.), and during the next twelve hours to 130° F. (43-44° R.). Then raise within the next three hours to 145° F. (50-51° R.), and hold this temperature for three hours.

KILNING AMERICAN MALT FOR DARK BEER.

Time of kilning, 24 hours.

On the upper kiln the malt is heated in five hours to 90° F. (25-26° R.), in the next two hours to 120° F. (39° R.), held during the next five hours at 120° F. (39° R.). Now dumped

on lower floor, brought in two hours to 140° F. (48° R.), in the next five hours to 180° F. (65-66° R.), in the next two hours to 220° F. (84° R.), held here two hours, and unloaded.

MECHANICAL MALTING OPERATIONS (AMERICAN).

Drum Malting.—Take for a sample a plant of fifty drums, using a Wisconsin barley, which is representative of the average qualities of barley used for trade malt. This barley runs about forty-eight pounds to the bushel.

There is little difference in steeping for drum malting from steeping for floor malting. The barley is steeped for about forty-four hours at 50-55° F. The water is forced in at the bottom of the steep tank, and also drained off at the bottom, except for the first hour or so, when it is kept flowing so as to carry off the skimmings from the top, a workman standing over the tank and helping in the removal of the skimmings. After that, the water is shut off and the mixed grain and water allowed to stand about ten to eleven hours. The water is drained off and renewed four times within forty-four hours at about equal intervals.

When the desired degree of steepage has been reached, the water is drained off completely, which takes about three hours for a tank of 250 bushels. A spout in the hopper-bottom of the tank is then opened, and the grain runs into the drum, which is located on the floor below right under the steep tank, and calculated to hold just one full charge of the tank. When the drum is full it is started revolving. The temperatures are kept as follows: First day 55° F., second day 60° F., third day 65°, fourth day 70°, fifth day, first half, 75°, the last 12 hours being given to air-drying or withering. Every drum having a thermometer, the temperatures can be readily regulated by increasing or reducing the draft of air or giving an extra turn of the drum so as to turn the malt if it sweats too much.

The drum is turned about as follows: For the first three days, one full revolution every two hours; fourth day, every 1½ hours; first half of the fifth day, the same; after which the drums are kept revolving for 12 hours, making one revolution in about 40 minutes.

The drum is connected with an air shaft leading from the coke tower or atomizing room, where the air is drawn through coke and water, so as to be filtered and at the same time charged with moisture. The air is drawn through the drum by a la

About 12 hours before germination is finished, that is, when the continuous revolutions of the drum begin, this moist air supply is shut off, and air drawn through from the room itself, so as to dry the malt. It thus becomes much drier than floor malt when it reaches the kiln.

While in the drum, the grain is sprinkled twice with a hose, about one barrel of water being given for a piece of 250 bushels. After each sprinkling, the drum is given an extra turn, so as to mix the grain and water well. The first sprinkling is given after the grain has well broken out, answering about to the stage of the third day on the floor. About 12 to 14 hours later, sprinkle again.

At the end of the fifth day, when the acrospire has reached a length of $\frac{3}{4}$-$\frac{7}{8}$ of the grain, and the malt has been air-dried as described, it is dropped through the door of the drum into a trough running along the floor, several men being sent into the drum to shovel it out. In the trough an ordinary worm conveyor pushes the malt to the dry-kiln adjoining the malthouse. The charges of ten drums, aggregating about 2,500 bushels, are unloaded and conveyed to the kiln in about two hours.

The dry-kiln has the usual two floors, open fire, vents and dampers. Besides, it has an automatic turning device, which travels along the railing of the floor, with blades to scrape up the malt from the floor and worms to carry it to the surface, so as to turn it thoroughly. The temperature on the upper floor is kept at 90° F. for the first twelve hours, then raised to 100° for the next twelve hours. The vents are so regulated as to carry off the vapors, which are much less than with floor malt, owing to the air-dry condition when the malt reaches the kiln, and the dampers set to maintain the temperatures. At the expiration of twenty-four hours the charge is dumped on the lower floor, where it starts at 110°, and is kept at that temperature for twelve hours. The last twelve hours the heat is regulated according to the desired product. If high-dried malt is wanted, the temperature is gradually raised and the last three hours kept at 200 up to 240°. For ordinary pale malt the final temperature should be about 170°.

After kiln-drying, the malt is treated the same as floor malt.

The drums are cleaned with water only, the men being sent into them with a hose, and flushing out by means of a force pump. One man can clean ten drums in 1½ hours. No disinfectants

are used in cleaning, the drums being varnished inside and incapable of holding dirt.

Barley of the Canada and California type requires six days in the drum.

A plant running fifty drums can be operated by eighteen men, including the superintendent and the warehousemen, shipping clerk, etc. It will produce 2,500 bushels a day. The establishment need be but two stories high and 50x300 feet in extent. The power plant consumes about seven tons of coal at $1.10 a ton daily, including elevators, dynamo, etc.

Pneumatic Floor Malting.—For pneumatic floor malting the grain is steeped in the same manner as for drum malting. Upon reaching the desired steepage the whole charge of the tank, grain and water together, is shot into a compartment below instead of a drum. The compartments are so designed as to hold a full charge of a steep tank, and have drains to carry off the water.

When charged, the malt lies about thirty to thirty-six inches high on the perforated floor, after it has been properly leveled. The drafts and fans are set in operation and the air sucked through the grain. In many cases, of late, a downdraft of air has been introduced, instead of the upward current originally designed for this system. The velocity of the draft and its saturation with moisture should be regulated, as nearly as can be, to suit the condition of the piece it is to pass through, being increased if the temperature rises too high, and diminished if it drops too low. The malt is turned about the same as in floor malting, and sprinkled as may be required.

When the desired growth has been reached, the malt is scraped out of the compartment into the conveyor, and taken to the elevator which carries it to the kiln.

In all other respects the treatment does not differ from that above described for the other methods of malting.

The floors are kept clean by scrubbing with brushes and the usual chemicals.

MALTING IN ENGLAND.

QUALITY OF ENGLISH MALT.

According to Sykes, a good sample of malt should be evenly grown, the acrospire should be from two-thirds to three-quarters up the back, and it should not contain more than 2 per cent

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"idlers." The endosperm should be tender and friable; the corns should be crisp, and, when bitten, should crumble between the teeth; a broken corn, when drawn across a board, should leave a mark such as a piece of chalk would do. Malt, on leaving the kiln, should be practically free from moisture. If a malt has absorbed even small quantities of water, it rapidly deteriorates, slack malt being one of the most frequent causes of trouble in the brewery. Broken corns should not exceed 2 per cent. Malt should not be used until it is about six weeks old. It should have a pleasant aromatic odor. The weight should be 40 to 44 pounds to the bushel.

The amount of extract may vary from 75 to 95 pounds per quarter. The diastatic power ranges between 30° and 45°, according to Lintner's scale. The diastatic power of green malt ranges from 110° to 125°. The acidity is usually 0.2 to 0.3 per cent, and should not exceed 0.4, figured as free lactic acid. The amount of ready-formed sugars, according to Moritz & Morris, should not exceed 16 per cent, except in the case of very highly dried samples. Malts containing a higher percentage than this are stated to give bad results in brewing, while abnormally low percentages (under 10 per cent) point to insufficient germination.

STEEPING.

According to Thatcher, the steeping liquid employed should not be above 54° nor below 50° F. The water should be drawn off from the bottom of the cistern every 12 hours, adding fresh at the top in the form of a sponge. This should be kept going with the waste top open five to ten minutes. Afterward the cistern may be filled. The grain should be steeped until it is soft enough to be pierced by a pin. The skin should be easily removed, and the grain broken by the thumb-nail. A short steep takes 40 to 47 hours, a long steep 80 to 85, an average steep 56 to 60 hours. Sprinkling should be resorted to only upon necessity. Bisulphite of lime may be used in the steep, about half a gallon to every quarter of barley on the second day of steeping, or 3 to 5 ounces for every four gallons of water, if applied during sprinkling.

GROWTH ON THE FLOORS.

The grain may lie upon the floors 2 to 10 inches high, according to the judgment of the maltster. As growth proceeds, the thickness is lessened. The proper temperature in the grain from

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the commencement of the steep during the whole time it is upon the floors is 50° to 54° F. Higher temperatures develop mold and force the grain too much, resulting in fretty fermentations. The grain should be ploughed or turned every 3 to 5 hours. Sprinkling, if done at all, should take place when the growth of the grain flags; it should not be later than the fifth or seventh day after the grain has left the cistern. Plenty of air is necessary for success. Germination on the floors takes 10 to 15 days.

Germination is arrested by withering. This should not take place upon the kiln, but upon the floors by spreading the malt very thinly. The grain, when properly withered, should be fairly dry and floury if opened and pressed by the thumb-nail. All foreign barley should have the acrospire grown right up without piercing the end. For English barley the acrospire should be grown right up when high mash tun and kiln temperatures are used. For beers intended to have great palate-fullness the grain should not be grown so far. Where low primary mash tun temperatures are used the malt must not be grown so freely. It must be dried higher on kiln. For stouts and porters and sweet beers, and where the ales are required for long storage, a large amount of dextrin is desired to prevent undue early attenuation. In these cases the growth of acrospire and diastase on the kiln must be severely checked.

KILNING.

Depth on kiln, 4 to 6 inches. Until practically hand-dry it is only safe to fork the malt, but afterward it may be thoroughly turned. The first day the temperature should not be higher than 95° to 100° F. When the greater proportion of moisture is expelled, generally on the second day, raise the temperature slowly to 120° F., the third day slowly to 140° to 150°, the fourth day dry off at the desired limit for whatever quality of malt is required, which varies from 185° to 200° F. for pale malts, and 200° to 225°, or even 230°, for high-dried malts. In all cases, the grain must be kept at the drying-off heat for at least 5 to 6 hours. The temperature is measured by introducing the thermometer into the grain, and this temperature should be the same in any part of the kiln. After being properly dried the malt must be allowed to cool gradually, when it is trodden to remove the rootlets. Then the malt should be well heaped up on the kiln, after whic

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it is stored in bins which are generally placed around the exterior of the kiln walls on account of the dryness and warmth of the position. It should remain on storage 6 to 8 weeks or more, before being used.

Southby says that drying and curing cannot be properly accomplished under from three to four days, including the time required for loading and unloading. He recommends bringing the whole load of the kiln up to 130° F., with as little delay as possible. This temperature must not be exceeded until the bulk of the moisture is expelled, and the moisture should be reduced to about 6 to 7 per cent by the time the temperature reaches 140°. About 3 to 4 per cent more of the moisture ought to be expelled by the time the temperature arrives at 155°, which should be when the kiln has been loaded for about 60 hours. Another 12 hours and the temperature should have risen to about 175° F., and then it should be maintained at 175° to 185° for the following 12 hours, when the malt will be perfectly dried and cured, and can be at once removed from the kiln.

The moisture of the perfectly dry malt should not exceed 1.5 per cent, and is frequently found less than 1 per cent. Perfectly dry malt, according to Southby, will keep forever without deterioration at the temperature of very hot climates.

Besides pale malt there is used: Amber malt, which is simply pale malt that has been subjected to a high final temperature on the kiln so as to give it some color and destroy the action of the diastase.

Blown or Brown Malt, which is dried rapidly over a fire of beech or birch wood. This has a much higher color than amber malt, and contains but little, if any, diastase.

Black or Patent Malt, which is absolutely roasted like coffee, and the roasting should be so carried out as to produce the largest amount of soluble coloring matter.

Crystal Malt is prepared by moistening the malt during the drying process with a solution of sugar and then drying it off at a high temperature.

Besides these, *caramel malt* may also be employed.

For pale ales only the palest malts can be used. For mild ales, pale malt is used with a little black malt. Porter and stout are brewed in Dublin from high-dried pale malt and black malt only, while London brewers generally prefer a grist containing all

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the three qualities of colored malt, viz., amber, brown and black, in addition to the pale malt. When black malt only is used in brewing porter and stout, one of black, by measure, to seven of pale is sufficient for the blackest beers, and one of black to twelve of pale is about the smallest proportion used even in Ireland where the black beers are generally far less highly colored than in London.

MALTING IN GERMANY.

QUALITY OF GERMAN MALT.

Three types of malt are distinguished in Germany, viz., Bohemian, Wiener and Bavarian. In the production of all of these two-row barley is universally employed. In regard to purity, that is, freedom from dust, foreign seeds, etc., appearance, color of husk, condition of endosperm, color and general appearance of sprouts, length of acrospire, the same general remarks apply as to the valuation of American malts. As to the taste or aroma of the malt, that of the Bohemian type should have no caramel and very little malt aroma; the Vienna malt, on the other hand, should possess it distinctly, and in the Bavarian this aroma should be very strong, without a bitter empyreumatic taste.

In the following are given some of the most important characteristics of German malts from laboratory examinations, according to Thausing.

a. Amount of Moisture.—This differs according to whether the malt is kiln-dried, low or high. Taken fresh from the kiln it contains 1.5 to 3.5 per cent of moisture. When properly stored it absorbs 2 to 3 per cent of moisture, so that when ready for brewing the malt will have about 3.5 to 6.5 per cent.

b. Aroma of the Malt Mash.—This should always be pure, whether it is neutral, as for pale malt, or weakly aromatic, as for Vienna malt, or strongly aromatic, as for Bavarian. During the process of mashing the odor changes constantly.

c. "Break" of the Malt Mash.—If at the end of the mashing period the mash beakers are allowed to stand quietly, the grains will settle and the wort over them will appear clear. If this takes place quickly it is a good sign.

d. Power of Inversion, Diastatic Power.—After the mash in the beaker has reached a temperature of 70° C. (158° F., or 56° R.) in carrying on the laboratory mash (see Examination of Malt in *the Laboratory*), the time up to the point of complete

saccharification (Verzuckerungszeit) should be for Bohemian malt 10 to 20 minutes, for Vienna malt 25 to 35 minutes, for Bavarian malt 35 to 45 minutes.

(American malts almost invariably show complete saccharification when the end temperature of the laboratory mash is reached. Their diastatic power is, as a rule, greater than that of Bohemian malts.)

e. Filtration of the Wort.—The quicker the wort runs from the filter, the better. High-dried and freshly-dried malts yield worts with slower filtration than low-dried and stored malts because in the latter case the husk and endosperm is less finely crushed in the mill.

f. Appearance of the Wort.—While flowing from the filter the wort may look brilliant, clear, slightly opalescent, strongly opalescent, or turbid. Wort must never be turbid at this point, or opalescent, but always clear and, better still, brilliant. Bavarian malts more often yield worts that do not run clear than do malts of paler color, which fact indicates that this malt, which was exposed to high temperatures in the kiln, was not sufficiently grown when it reached the kiln or was improperly treated in the kiln, generally being taken out too early.

The color of the wort should be as near as possible that of the beer to be produced. It is described more minutely as light or dark Vienna and light or dark Bavarian. For Vienna beer it is not desirable to use color malt for deepening the color, which cannot be avoided, however, for Bavarian beers. The paler the color of the wort, the shorter should be the time of complete saccharification, and the more sugar may and should the wort contain. It is customary to determine the color of the wort by normal iodine solution. Light malts give worts with a color equivalent to 0.1 to 0.3 iodine solution, medium light worts 0.3 to 0.6, dark worts 0.7 to 1.5. The different color tints of the scale are obtained by strongly diluting a 0.01 normal iodine solution (1.27 g. iodine in 1 l. water brought into solution by 4 g. iodide of potassium). Color No. 1 is a solution which contains in 100 c.c. of volume 5 c.c. of 0.01 normal iodine solution, so that the iodine solution for the color 0.1 contains only 0.5 c.c. of 0.01 normal iodine solution in 100 c.c., etc. (See also laboratory tests in *Brewer's Chemical Laboratory*.)

g. Yield.—The yield is given either in kilograms of extract

per 100 kilograms of air-dry malt (containing water), or per 100 kilograms of malt in a water-free condition. (This practice is also followed in the laboratory of Wahl & Henius.) The yield calculated on malt in a water-free state varies from 70, 75 to 78 per cent. A yield under 70 per cent is very low, over 78 per cent very high, a good average being 75 per cent. (The average in American malts is about 1.5 per cent less.)

h. Sugar in Extract (ratio of sugar to non-sugar).—A good Bohemian malt will give a higher sugar percentage than a Vienna malt of equal grade, and a Vienna, in turn, a higher one than a Bavarian. Generally speaking, a Bohemian malt will give 51 to 52.5 per cent, Vienna 48 to 49.5, Bavarian 45 to 48 per cent of sugar, or, rather, copper reducing substances (Rohmaltose), given in percentage of water-free malt.

Prior gives the following table:

COMPOSITION OF TYPICAL GERMAN MALTS (PRIOR).

	Pilsener Malt.	Wiener Malt.	Bavarian Malt.
Reducible sugar in extract.....	63 to 70 p. c.	67 to 69 p. c.	62 to 66 p. c.
Cane sugar in extract..........	3 to 5 p. c.	4 to 6 p. c.	6 to 10 p. c.
Time of saccharification........	10 to 20 min.	15 to 25 min.	20 to 45 min.
Odor and taste of malt.........	slightly green	no aroma or only slight	aromatic, sweet
Color of wort in 0.1 c.c. normal iodine	0.2 to 0.25 c.c.	0.3 to 0.4 c.c.	0.7 to 2.0 c.c.

In the production of Bavarian beers caramel malt or color malt is generally employed. Prior obtained from 100 parts of caramel malt 57.78 parts of extract, which showed the following compositions:

COMPOSITION OF CARAMEL MALT EXTRACT (PRIOR).

Cane sugar..	2.45 p. c.
Reducible, readily fermentable sugars (chiefly maltose, dextrose and levulose)..................	11.02 p. c.
Hard fermenting sugars (chiefly isomaltose).......	13.04 p. c.
Dextrins, roasting products, nitrogenous compounds, mineral matters	31.27 p. c.

STEEPING AND FLOORING.

Leyser-Heiss recommends renewing the steep water every 12 hours if the water has a temperature of 7° to 10° R. (48° to 54.5° F.). Under unfavorable circumstances the water should be renewed every 6 to 8 hours. The steeped barley is spread on the floor at a depth of 0.3 to 0.5 m. (11.8 to 19.7 inches) so that the

barley does not lose too much water. To spread the grain (Nasshaufen) lower is advisable only in case the barley has been oversteeped. The couch is turned every 10 to 12 hours. The heaps are gradually thinned out and turned if the temperature in the "Brechhaufen" has increased 3° to 4° R. (6.75° to 9° F.) above the temperature of the room, in the "Junghaufen" if the increase is 4° to 6° R. (9° to 13.5° F.), in the "Althaufen" if the increase is 7° to 8° R. (15.75° to 18° F.). The "Brechhaufen" reaches this temperature after about eight hours, the "Junghaufen" after about six, and the "Althaufen" eight hours. The maximum temperature should be 17° to 18° R. (70° to 72.5° F.), and the period of germination 6 to 8 days. At the end of the germinating period, especially if the desired degree of mellowness has not been reached, the heaps may be left for 18 to 24 hours to mat (angreifen lassen). Sprinkling should, according to Leyser-Heiss, take place during the first stages of growth, i. e., the stage of the "Nasshaufen," using about 40 to 50 liters of water for every 55 hectoliters of malt. The grown malt is taken to the air-drying floor (Schwelke), where it is spread not more than 0.05 m. (about 2 inches) high, except if the mellowness is to be increased by the further growth on the drying floor, or to prevent freezing in winter.

The three different types of beer known as Bavarian, Wiener and Bohemian, require correspondingly different treatment of the malt from which they are produced. The malt for dark Bavarian beer should have a strong malt flavor, a darker color of the endosperm and less diastatic power than the Bohemian malt from which the light-colored beers, with relatively more alcohol and less extract, are produced, in which the aromatic malt flavor is but very little pronounced compared with Bavarian beers, while in the production of the Wiener type of beers a malt is employed which may be considered as standing between the Bavarian and the Bohemian types.

The following description of operations, condensed from Michel's "Lehrbuch der Bierbrauerei,' will be found useful in understanding the systems of malting as employed in the production of these three typical German beers.

MALT FOR BAVARIAN BEER.

Since Bavaria grows barley of excellent quality and in sufficient quantities, very little barley is imported in that country.

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The steep water is about 10° R. (54.5° F.). Time of steeping, 90 to 120 hours. Amount of moisture taken up by the barley, 44 to 45 per cent. The duration of steeping is longer than in the production of Wiener and Bohemian malts. Sprinkling is, therefore, not necessitated to the same degree. The grain is then spread on the floor 20 to 25 cm. (about 8 to 10 inches) high, and is turned in the morning and evening. As soon as the temperature begins to rise the height of the heap is reduced. The heaps are turned regularly every 12 hours, unless the temperature rises too high, until the fifth or sixth day, at which time the malt should show a strong development of radicle. It is then allowed to lie 15 to 18 hours in order to mat. Generally the malt is allowed to mat twice, and if necessary, the temperature is supposed to rise to 18° R. (72° F.).

FLOOR RECORD OF A SAMPLE MALT FOR BAVARIAN BEER.

Time of Turning.		Temperature in Heap	Remarks.
Day.	Hour.		
1	6 p. m.	8° R.	
2	6 a. m.	8.5° R.	
2	6 p. m.	9° R.	Malt begins to chit.
3	6 a. m.	10° R.	
3	6 p. m.	12° R.	
4	6 a. m.	14° R.	Radicles begin to show.
4	4 p. m.	16° R.	
4	12 p. m.	17° R.	Abundant sweat. Heap thinned out.
5	12 m.	17° R.	Allowed to mat.
6	9 a. m.	18° R.	Matting has taken place.
7	9 a. m.	18.5° R.	Malt strongly matted.
8	9 a. m.	17° R.	Matting has progressed but little.

The temperature in the room was kept at 7° to 8° R. (48° to 50° F.). Height of malt kept at 20 cm. (about 8 inches) during the first 5 days, and reduced to 18 cm. (about 7 inches) for the last 3 days. The radicle in many corns exceeded one and one-half times the length of the corn, the acrospire reaching three-quarters of the length in a majority, when the malt was ready to go on the kiln.

KILNING MUNICH MALT.

The total time of kilning is forty-eight hours. During the first twenty-four hours the green malt rests on the upper floor, being spread about ten inches thick, and receiving such temperatures as naturally follow from the regulation of heat on the lower floor, given below.

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After the malt has been dumped from the upper to the lower floor—the upper being loaded afresh with green malt—the temperature for the first twelve hours in the lower chamber under the upper floor is kept at 104° to 111° F. (32° to 35° R.). The drafts or dampers are then gradually closed, and the temperature of the lower chamber slowly and steadily raised during the following six hours, at the end of which time the heat should be 133° to 140° F. (46° to 48° R.). During the remaining six hours the malt is heated slowly—the temperature being raised steadily and uniformly, during three hours, up to the final temperature, at which the malt is kept for the final three hours, the dampers being closed tight during that period.

The temperatures at the different stages, from hour to hour, for the final six hours, are given below. These figures can serve only as a general guide, subject to the judgment of the maltster during this last critical period of malt-making.

TEMPERATURES FOR THE LAST SIX HOURS ON LOWER KILN FLOOR FOR MUNICH MALT, ACCORDING TO MICHEL.

Hours.	Temperature on Kiln Floor.		In Malt.		Air in Lower Chamber.	
18 to 19	207° F.	78° R.	180-183° F.	68-70° R.	140-149° F.	48-52° R.
19 to 20	227°	87°	194-198°	72-74°	149-156°	52-55°
20 to 21	239°	92°	207-212°	78-80°	153-162°	55-58°
21 to 22	250°	97°	212-216°	80-82°	162-167°	58-60°
22 to 23	250°	97°	216-221°	82-84°	167-171°	60-62°
23 to 24	250°	97°	221-223°	84-85°	171-183°	62-67°

The lower kiln is then cleared, and the malt from the upper floor dumped down on the lower, and the upper floor freshly loaded with green malt.

MOISTURE IN MALT OF MUNICH TYPE.

On reaching upper kiln........	37 to 40 per cent.
After the first 12 hours.......	20 to 24 per cent.
After the next 6 hours........	10 to 14 per cent.
After the next 6 hours........	5 to 6 per cent.
Finished malt................	$1\frac{1}{2}$ to 2 per cent.

MALT FOR WIENER BEER.

Barley with as light a color as possible is used. Steeping period, 57 to 84 hours. Moisture after steeping, 38 to 42 per cent. The *temperature of the* couches should never rise higher than 15° R. *(66° F.), and at the* time when the rootlets begin to develop

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should not be over 12° R. (59° F.). Growth throughout is slower and at lower temperatures than in the production of Bavarian malt, the germinating period lasting 9 to 10 days. It is of special importance to obtain as strong and perfect a development of acrospire as possible, while the radicle remains somewhat shorter. The heaps are turned every 6 to 8 hours. The malt is never allowed to mat.

FLOOR RECORD OF A SAMPLE MALT FOR WIENER BEER.

Height of Heap.	Days.	Weight.	Temperature.
18—16 cm. (7—6.3 in.)	1.	3 Times.	8—11° R. (50—57° F.)
15—14 cm. (6—5.5 in.)	2. Brechhaufen	4 "	11—14° R. (57—63.5° F.)
12—14 cm. (4.7—5.5 in.)	3. Junghaufen.	5 "	15—16° R. (66—68° F.)
12—13 cm. (4.7—5 in.)	4. Wachshaufen.	5 "	16° R. (68° F.)
13—14 cm. (5—5.5 in.)	5. "	3 "	16° R. (68° F.)
14 cm. (5.5 in.)	6. Althaufen.	2 "	16° R. (68° F.)
14 cm. (5.5 in.)	7. "	2 "	16° R. (68° F.)
14 cm. (5.5 in.)	8. "	1 "	16° R. (68° F.)

The grown malt is generally taken directly from the malt floor to the upper kiln and is spread 12 to 18 cm. (about 4.5 to 7 inches) high. The malt is air-dried at 28° to 30° R. (95° to 100° F.), all the draughts being opened. As soon as the malt is air-dry, the draught is checked and the temperature raised to 50° to 55° R. (144° to 156° F.), time of kiln drying, about 24 hours.

KILN RECORD OF A SAMPLE MALT FOR WIENER BEER FOR THE LAST 12 HOURS.

On lower kiln floor. Temperature in degrees R.	Hours. I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
In the air	23	24	26	28	30	33	38	43	51	64	67	67
In the malt	35	38	40	40	48	52	55	62	68	75	76	80

MALT FOR BOHEMIAN BEER.

The barley should be of very light color and have a thin husk. Time of steeping, 57 to 72 hours. Amount of moisture in steeped barley, 38 to 42 per cent. Low temperatures are maintained. The first couch is made 20 cm. (about 8 inches) high, and the temperature in the room 8° to 10° R. (50° to 54.5° F.). If the temperature is lower, the couches are laid as high as 30 cm. (about 12 inches). Heaps are turned regularly in the morning and evening, until the radicles show development, i. e., until they become visible. After that the heaps are turned every 6 to 8 hours and spread lower. If the radicles have developed to half

the length of the corn (Junghaufen) and the heap at a temperature of about 12° R. (59° F.) after lying 12 to 15 hours shows only little sweat, the malt is sprinkled with about one-half to 1 liter of water per hectoliter of barley, and immediately turned and laid 12 cm. (about 4.5 inches) high. The heap is then left undisturbed until the temperature has risen to 14° R. (63.5° F.) or at most 16° R. (68° F.), which may take 12 to 18 hours. Time of growth, 9 to 10 days.

KILNING PILSENER MALT.

Time in kiln, twenty-four to thirty hours. Thickness of layer on upper kiln, six to eight inches. Temperatures of air in the lower chamber and in the malt on the lower floor for the last fifteen hours, taking the maximum duration of kilning of thirty hours, of which fifteen was spent on the upper floor.

Hours		1	2	3	4	5	6	7	8
Temperature of air in lower chamber	°F	77	77	81	81	90	95	99	111
	°R	20	20	22	22	26	28	30	35
Temperature of malt on lower floor	°F	100	100	113	113	115	117	120	131
	°R	30	30	36	36	37	38	39	44

Hours		9	10	11	12	13	14	15
Temperature of air in lower chamber	°F	117	122	126	131	156	156	156
	°R	38	40	42	44	55	55	55
Temperature of malt on lower floor	°F	144	149	151	153	178	178	178
	°R	50	52	53	54	65	65	65

Draft holes are kept entirely open during the first twelve hours of the fifteen, and are then gradually closed during the last three hours, up to one-fourth.

COLOR MALT.

According to Prior, color malt is produced by roasting malt moistened with a little water in revolving drums. This process should be carried on in such a way as to prevent the formation of assamar, which gives to the color malt a bitter taste. Color malts contain no diastase, but yield almost as much extract as ordinary malts.

Prior states he observed that ordinary malt fresh from the kiln filled into bins in a warm condition suffers deterioration on account of the temperature increasing materially, which, however,

is not the case if the malt has been first allowed to cool rapidly. Malt improves during storage for a time. If stored very long, however, it deteriorates, the more so, the greater the facility for the absorption of moisture.

CHEMICAL AND PHYSIOLOGICAL DATA AND PROCESSES.

According to Brown and Morris (Journal Chem. Soc., 1890), the diastase of the malt is formed during germination in the germ, not in the endosperm itself, diffusing gradually from the germ through the endosperm as growth proceeds. Diastase is only formed in such measure as required to satisfy the needs of the growing germ for food. The latter may be artificially fed by a solution of cane sugar, when no diastase will be formed. The diffusion of the diastase through the germ and transformation of the starch into food for the germ is preceded by the breaking down of the cell walls composed of cellulose, which envelop each starch granule. This destruction is effected by the enzyme cytase. The starch throughout the endosperm is changed into maltose which finds its way to the germ, but is here in turn transformed into saccharose before utilization as food.

Kjeldahl determined the diastatic power of malt during germination. Figured on the dry basis the following comparative amounts were found according to the Kjeldahl method (Meddelelser fra Carlsberg Laboratoriet II, 1879):

	Diastatic power.
1 day	70
2 days	73
3 days	80
4 days	105
5 days	150
6 days	190
7 days	220
8 days	226

During the first three days while the barley was in the steep, the diastatic power is about the same, and it changes but little during the first three days of growth.

According to Moritz & Morris the diastase is distributed *throughout the body* of the growing barleycorn quite unequally

The relative quantities, as given in terms of cupric oxide reduced, are:

	Grams Cu O
Diastase in 50 endosperm halves (germ end)...........	9.7970
Diastase in 50 endosperm halves (opposite end)........	3.5310
Diastase in radicles of 50 corns........................	0.0681
Diastase in acrospires of 50 corns......................	0.0456
Diastase in scutella of 50 corns........................	0.5469

CONSTITUENTS OF GREEN MALT.

The germinating malt, according to Prior, contains the following substances:

1. Water;
2. Cellulose;
3. Starch;
4. Cane sugar and raffinose or melitriose;
5. Glucose and levulose;
6. Gummy substances;
7. Fat;
8. Albumen, soluble and insoluble;
9. Peptones;
10. Amido acids;
11. Amides;
12. Ammonium salts;
13. Enzymes, viz., diastase, cytase, laccase, glucase, peptase;
14. Volatile and fixed organic acids;
15. Primary phosphates;
16. Mineral substances.

(See also "Chemistry" and "Brewing Materials.")

READY-FORMED SUGARS OF MALT, ACCORDING TO O'SULLIVAN.

	Barley I.		Barley II.	
	Before Germination.	After Germination.	Before Germination.	After Germination.
	Per cent.	Per cent.	Per cent.	Per cent.
Cane sugar.........	0.9	4.5	1.39	4.50
Maltose.............	...	1.2		1.98
Glucose............	1.1	3.1	0.62	1.57
Levulose...........	...	0.2	....	0.71
Total	2.0	9.0	2.01	8.76

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READY-FORMED SUGARS OF MALT, ACCORDING TO BROWN & MÒRRIS.

	Barley after 48 hours' steep.		Barley after 10 days' germination.	
	Embryos.	Endosperms.	Embryos.	Endosperms.
	Per cent.	Per cent.	Per cent.	Per cent.
Cane sugar.........	5.4	0.3	24.2	2.2
Invert sugar........	1.8	0.2	1.2	2.2
Maltose	...	...	....	4.5
Total	7.2	0.5	25 4	8.9

A. Hilger and F. van der Beeke (Archiv. f. Hygiene, 1890, 10, p. 477, from Prior's Chem. u. Phys. d. Bieres) investigated the changes that take place in the nitrogenous substances during the growth of barley. The following table gives results:

	Albumen Nitrogen. Per cent.	Peptone Nitrogen. Per cent.	Ammon. Nitrogen. Per cent.	Amido-acid Nitrogen. Per cent.	Amide Nitrogen. Per cent.
Raw barley.......	0.0600	0.0046	0.0169	0.0417	......
Steeped barley....	0.0354	0.0009	......	0.0294	......
Green malt.......	0.1671	0.0058	0.0290	0.1417	0.0505
Kiln-dried malt...	0.1194	0.0233	0.0057	0.2257	0.0029

Accordingly, the increase in the amount of soluble nitrogenous substances during germination would be as follows, the figures being for soluble nitrogenous substances in percentages of the total amount of nitrogenous substances contained in the water-free malt:

Raw barley......................	6.74 per cent
Steeped barley...................	3.75 per cent
Green malt 5 days................	21.96 per cent
Kiln-dried malt..................	24.44 per cent

Bungener and Fries determined the amount of soluble nitrogenous constituents of a sample of barley and of the malt made from it as follows:

	Barley. Per cent.	Malt. Per cent.
Total nitrogen	1.690	1.580
Nitrogen as albumen......................	0.161	0.230
Nitrogen as peptone......................	0.040	0.060
Nitrogen as amides precipitable by mercuric acetate	0.052	0.182
Nitrogen as amides not precipitable by mercuric acetate	0.154	0.352

Total soluble nitrogen...................... 0.355 0.642

(See also "Peptase and Albumen" in Chapter "Chemistry.")

NITROGENOUS SUBSTANCES IN DIFFERENT SAMPLES OF MALT WHICH HAD GIVEN GOOD RESULTS (SYKES).

	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Total nitrogenous matter................	8.1	9.2	9.4	10.0	10.1	11.8
Soluble nitrogenous matter..............	3.8	3.6	3.9	4.5	4.5	4.1
Coagulable nitrogenous matter..........	0.9	0.7	0.8	0.6	1.7	1.4
Proteoses and peptone..................	0.7	0.8	0.5	0.9	0.7	0.6
Amide..................................	2.2	2.1	2.6	3.0	2.1	2.1

FLINTY AND MEALY CORNS.

The difference between hard and mealy corns in malt was investigated by Prior, with the following results:

	Mealy Corns.	Flinty Corns.
Water	11.45 p. c.	11.23 p. c.
Yield of extract	67.43 p. c.	62.40 p. c.
Reducing sugar in extract	61.93 p. c.	61.19 p. c.
Cane sugar in extract..............	5.99 p. c.	5.43 p. c.
Total sugar to non-sugar..........	1 : 0.47	1 : 0.50
Diastatic power	14.81°	16.00°
Nitrogenous matters	10.19 p. c.	10.19 p. c.
Calculated for dry matter:		
Yield of extract	76.15 p. c.	70.29 p. c.
Diastatic power	16.73°	18.02°
Nitrogenous matters	11.48 p. c.	11.51 p. c.
Of which passing into wort.......	2.82 p. c.	2.28 p. c.
Precipitated by boiling	0.74 p. c.	0.68 p. c.
Remaining in solution	2.07 p. c.	1.60 p. c.
Behavior of malt and wort:		
Saccharification	45 min.	more than 60 min.
Drainage of wort	quick.	quick.
Condition of wort.......	slightly opalescent.	opalescent.
"Break" of wort in boiling	fair.	bad.
Color of wort...........	0.8	0.4

The tables lead to the following conclusions:

1. The water content of mealy and flinty corns is equal. The *difference in the condition* of the endosperm, therefore, is physical *and independent* of the water content.

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2. The yield of extract of the mealy corns is considerably in excess of that of the flinty ones.

3. The amount of reducing sugar in the extract of the mealy corns is about 1 per cent greater than in the extract of the flinty corns, and that of cane sugar about 0.5 per cent.

4. The diastatic power must be taken as equal in both, but should certainly be greater for the mealy corns if in the solution of the material for the tests the white mealy berries had been picked out instead of being mixed with brown mealy kernels. This is demonstrated by the color of the wort, which is twice as dark for the mealy corns. In that case the difference in the sugar contents of the extracts would also be greater.

5. The total amounts of nitrogenous matters are equal, but in the mealy corns 0.54 per cent more of these matters pass into solution than in the flinty ones. The amounts precipitated by boiling are equal.

6. The mealy corns saccharify completely in 45 minutes, whereas the flinty ones were not saccharified in 60 minutes. The diastatic power being equal, the greater stubbornness in saccharification is due wholly to the physical condition of the flinty corns, in which respect they are very different from the mealy ones. The difference of reducing sugars must also be attributed, in the present case, to the differences of physical condition, not to any difference in diastase contents.

7. The wort which was obtained from the mealy corns was slightly opalescent, i. e., it had a faint haze. In boiling it had a fair "break," whereas the wort from the flinty corns was strongly hazy and "broke" badly in boiling. This behavior is probably connected with the modification of the nitrogenous matters during germination, such as the formation of peptones and amides, which is more extensive in the more mellow, mealy corns. The greater amount of soluble nitrogenous matters in the wort from the mealy corns may be due to the same cause.

The investigation shows that the white, flinty corns in malt are quite unfit for brewery use, and that any considerable percentage of them materially detracts from the quality of the malt.

Glassy or stony malt, according to the scientific station of Nuremberg, contains no diastase, or only traces of it. If mashed by itself it gives worts of a deep brown color, containing large quantities of unconverted starch.

INFLUENCE OF DRYING TEMPERATURES ON PROPERTIES OF MALT (PRIOR).

Temperature in °R.	35°
Water in per cent	8.44
Diastatic power	122.7
Diastatic power calculated for dry matter	134.0
Time of saccharification	7 min.
Maltose in extract in per cent	74.57
Maltose to non-maltose	1:0.34
Color of wort in c. c. 0.1 normal iodine solution	....
Brown corns in per cent	....
Decrease of water content in per cent	....
Decrease of diastatic power calculated for dry matter	....
Decrease of maltose content in per cent	....
Increase in depth of color	....

INFLUENCE OF DRYING TEMPERATURES ON PROPERTIES OF MALT.

The influence exercised by temperature in air-drying and kilning malt upon the properties of the product and the composition of the worts obtained in the mash is explained by investigations by Prior, the results of which are laid down in the tables above. The experiments were directed particularly to those modifications which the malt undergoes at different temperatures with respect to water content, diastatic power, sugar content in extract of worts, color of worts, time of saccharification, and condition of endosperm.

The conclusions are as follows:

MOISTURE.

The water content diminishes steadily with the temperature.

DIASTATIC POWER.

The diastatic power decreases materially at such low temperatures as 45° and 50° R. (133° and 144.5° F.), but the decrease at these temperatures remained equal. It follows that when the temperature of the malt on the kiln has reached 45° R. (133° F.) the diastatic power does not suffer by a further advance up to 50° R. (144.5° F.). This is true, however, only if the water content does not exceed 8 to 9 per cent when this temperature sets in, and if the kiln floor does not have a higher temperature, for the succeeding sample which had been heated at 55° R. (156° F.) shows a further diminution of diastatic power of 12.4 as com-

INFLUENCE OF DRYING TEMPERATURES ON PROPERTIES OF MALT (PRIOR).—Continued.

45°	50°	55°	60°	65°	70°	75°	80°
6.15	5.89	4.41	4.31	3.88	3.17	2.36	1.74
80.0	80.0	69.44	69.44	63.90	45.67	25.77	14.81
85.2	85.0	72.6	72.6	66.5	47.2	26.4	15.1
8 min.	10 min.	10 min.	10 min.	12 min	13 min.	20 min.	26 min.
74.82	74.68	72.88	70.62	69.76	68.59	63.86	60.75
1:0.34	1:0.34	1:0.37	1:0.42	1:0.44	1:0.46	1:0.57	1:0.65
0.25	0.25	0.3	0.3	0.4	0.5	1.75	2.5
....	....	0.5	1.0	2.5	7.5	29.0	37.0
2.29	2.55	4.03	4.13	4.56	5.27	6.08	6.70
48.8	49.0	61.4	61.4	67.5	86.8	107.6	118.9
....	....	1.81	4.07	5.03	6.10	10.83	13.94
....	....	0.05	0.05	0.15	0.25	1.5	2.25

pared with the preceding period. The decrease in malt heated to 60° R. (167° F.) is equal once more to that heated to 55° R. (156° F.), so that the same is true for these two temperatures as for the two preceding ones, with regard to the diastatic power.

From 60° R. (167° F.) upward the diastatic power diminishes every 5 degrees at a rate which increases with the rise of temperature and is quite substantial at the temperatures 70°, 75° and 80° R. (189.5°, 201° and 212° F.), amounting finally to 118.9°.

Calculating the diminution of diastatic power per hour of heating time, the following values are obtained:

Temperature	45°	50°	55°	60°	65°	70°	75°	80°
Diastatic Power	4.1	4.1	5.1	5.1	5.6	7.2	9.0	9.9

SACCHARIFICATION.

The time required for saccharification increases in proportion to the decrease of the diastatic power.

MALTOSE IN EXTRACT.

The maltose (sugar) content in the extract remained the same in the two samples treated at 45° and 50° R. (133° and 144.5° F.) as in malt that was first air-dried at 35° R. (111° F.). But the diastatic power having fallen from 134° to 85°, the greatest possible sugar production takes place in the mash even at a diastatic power of 85° under the prevalent conditions. Hence, it is quite immaterial for the amount of sugar formed in the extract whether the diastatic power is 85° or more.

At the succeeding temperatures the maltose content in the extract decreases, the greatest decrease being 13.94 per cent at 80° R. (212° F.).

The diminution of the maltose content in the extract is not, in all probability, to be attributed to the decrease of the diastatic power exclusively, since the same diastatic power is observed in the samples dried at 55° and at 60° R. (156° and 167° F.), whereas the maltose content in the extract is 2 per cent less at 60° R. (167° F.). This is connected with the fact that roasting products begin to be formed at 55° and 60° R. (156° and 167° F.) from the carbohydrates of the malt.

COLOR AND AROMA.

The color of the wort up to 50° R. (144.5° F.) is the same as that of worts prepared from malts dried at 35° and 45° R. (111° and 133° F.). When 55° and 60° R. (156° and 167° F.) is reached the color begins to deepen, some individual corns turning brown, which confirms the observation of Lintner, Sr., that roasting products begin to be formed at these temperatures. From 65° R. (178° F.) upward the production of roasting products increases materially. Malt dried for 12 hours at 80° R. (212° F.) had acquired a somewhat bitter and empyreumatic taste. It is not advisable, therefore, in practical work, to maintain high temperatures too long.

The best temperature for obtaining aromatic malt, according to Prior, is between 65° and 70° R. (178° and 189.5° F.). It seems advisable to prolong the time of kilning at medium temperature of 65° to 70° R. (178° to 189.5° F.), to extend the roasting process above 75° R. (201° F.) for not too long a time and not exceed 80° R. (212° F.) for the final temperature, or at least not materially. This proceeding serves to yield enough roasting products while the diastatic power of the malt is preserved as far as necessary, and the formation of substances having, and imparting to the beer, an empyreumatic and bitter taste is avoided.

The malt prepared with a maximum temperature of 50° R. (144.5° F.) has been designated as Pilsener malt, but as it contains noticeable, though not large, quantities of roasting products it approaches more nearly the character of a Wiener malt. In preparing Bavarian or Munich malt the aim should be to obtain

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the largest practicable amount of roasting products, that is, to have a high final temperature of 80° to 85° R. (212° to 223° F.) in the malt, and to take care that the malt while exposed to temperatures from 45° to 60° R. (133° to 167° F.) still retains sufficient moisture, as the conditions necessary for the formation of roasting products exist only in the presence of sufficient moisture.

According to Lintner, the products of torrefaction or roasting products, like caramel, are produced from isomaltose, this substance, as he supposes, changing with quite low temperatures (51° R. = about 147° F.), and forming aromatic substances of a dark color (caramel). Since it has not been possible, however, to detect isomaltose among the products of starch inversions, this hypothesis must be dropped. According to Prior, it is more probable that levulose furnishes the caramel, inasmuch as levulose is a constituent of green malt and caramelizes readily, especially in the presence of moisture and acids. Levulose also caramelizes at higher temperatures in a dry state.

F. R. Czerny found ("Allg. Brauer u. Hopfen-Ztg.," 1893, p. 1059) that malts with particularly well developed acrospire are rich in torrefaction products if they are treated accordingly in the kiln, i. e., if they are subjected to higher temperatures in the presence of proper amounts of moisture.

During malting much acidity develops. Prior determined the amounts of volatile and fixed organic acids, as well as the primary phosphates formed during malting in a Bavarian barley. The total phosphates were also determined. (See table, page 626.)

From these results it appears:

In green malt two days on the floor (Brechhaufen) the acidity has somewhat increased, the volatile acids either remain the same —for Bohemian barley—or increase slightly—for Bavarian barley. The fixed organic acids show a decrease, while the primary phosphates show an increase in about the same measure as the fixed organic acids diminish.

From the second to the fourth day the total acidity is increased in a high degree on account of the formation of acid phosphates, while the amount of volatile acids remains the same. From the fourth *day to the sixth*, the total acidity of the green malt from

ORGANIC ACIDS AND PHOSPHATES IN MALT (PRIOR).

Figures indicate number of c.c. 0.1 normal soda solution required per 100 g. malt.	Bavarian Barley. Barley.	Bavarian Barley. Steeped Barley.	Bavarian Barley. Green Malt. 2 day.	Bavarian Barley. Green Malt. 4 day.	Bavarian Barley. Green Malt. 6 day.	Bavarian Barley. Green Malt. 8 day.	Bohemian Barley. Barley.	Bohemian Barley. Steeped Barley.	Bohemian Barley. Green Malt. 2 day.	Bohemian Barley. Green Malt. 4 day.	Bohemian Barley. Green Malt. 6 day.	Bohemian Barley. Green Malt. 8 day.
Water	13.54	45.24	42.60	45.37	43.43	43.22	13.47	48.83	45.62	45.79	44.84	45.47
Total acid	37.0	24.00	26.25	34.00	37.75	37.75	32.0	20.75	21.75	35.75	35.00	34.00
Volatile acid	6.5	2.38	3.13	2.75	2.88	2.63	4.75	3.00	2.75	2.63	2.50	2.50
Fixed organic acid	5.75	6.63	4.38	3.70	5.38	4.38	5.25	6.25	4.50	3.03	4.50	3.38
Primary phosphate	28.25	16.50	19.63	29.13	29.40	32.30	23.75	13.13	15.63	28.28	28.63	29.50
Corresponding P_2O_5	0.2006	0.1172	0.1394	0.2068	0.2086	0.2290	0.1686	0.093	0.1110	0.2015	0.2033	0.2095
Total P_2O_5 quantitatively	0.837	0.492	0.506	0.567	0.532	0.534	0.790	0.536	0.450	0.498	0.472	0.469
Figures indicate number of c.c. 0.1 normal soda solution required per 100 g. dry matter.												
Total acid	42.79	43.83	45.73	62.24	66.73	66.48	36.98	38.31	40.00	65.96	63.45	62.35
Volatile acid	7.52	4.35	5.45	5.03	5.09	4.63	6.07	5.54	5.06	4.85	4.53	4.58
Fixed organic acid	6.65	12.07	7.63	6.41	9.51	7.71	5.50	11.54	8.28	6.70	8.16	6.20
Primary phosphate	32.67	30.13	34.20	53.32	51.94	56.80	27.45	24.24	28.20	52.35	51.90	54.10
Corresponding P_2O_5	0.232	0.214	0.260	0.379	0.369	0.403	0.195	0.172	0.204	0.372	0.369	0.384
Total P_2O_5 quantitatively	0.968	0.898	0.882	1.038	0.923	0.941	0.913	0.989	0.827	0.910	0.856	0.860

the Bohemian barley increased somewhat, while that of a Bavarian barley diminished slightly. This difference may be due to a difference in the treatment, especially in the temperatures. From the sixth to the eighth day a slight decrease of total acidity is noted for both cases. The same is true of the volatile acids, while the fixed organic acids show a decrease on account of the chemical interaction with the phosphates in consequence of which a larger amount of primary phosphates were formed.

The acidity of the sprouts is much greater than that of the corns. Prior gives the following table on this subject:

ACIDITY OF MALT IN KILN (PRIOR).

	Water.	Total Acidity.	Volatile Acids.	Fixed Organic Acids.	Primary Phosphates.
Green malt	44.22 p. c.	31.75 p. c.	3.25 p. c.	6.75 p. c.	23.25 p. c.
Corns	39.24 p. c.	22.25 p. c.	2.75 p. c.	5.75 p. c.	21.00 p. c.
Sprouts	62.07 p. c.	40.00 p. c.	6.25 p. c	12.50 p. c.	25.00 p. c.
Calculated on dry matter:					
Green malt	....	56.92 p. c.	5.83 p. c.	12.10 p. c.	41.68 p. c.
Corns	....	48.14 p. c.	5.35 p. c.	9.46 p. c.	34.56 p. c.
Sprouts	....	105.46 p. c.	16.18 p. c.	32.96 p. c.	65.91 p. c.

During the air-drying of the malt (Schwelken) the acidity increases by the formation of fixed organic acids and primary phosphates, while the volatile organic acids diminish somewhat by volatilization with water vapors, thus proving that the physiological processes, which take place during germination of the malt, continue during the air-drying process. These changes can be seen from the following:

	Green Malt.	Air-Dried Malt.
Water	42.00 p. c.	8.44 p. c.
Reducing sugars	7.31 "	12.58 "
Fermenting capacity	51.55 "	122.7 "
Calculated on dry matter:		
Reducing sugars	12.53 "	13.74 "
Fermenting capacity	88.88 "	134.00 "

The acidity of malt during the kilning period has also been studied by Prior and is shown in the table on next page.

CHANGES OF ACIDITY IN AIR-DRIED MALT (PRIOR).

	Green Malt.		Air-dried Malt.	
	Bavarian Barley.	Bohemian Barley.	Bavarian Barley.	Bohemian Barley.
Water	43.82 p. c.	45.47 p. c.	17.39 p. c.	11.15 p. c.
Total acidity	37.75 c.c.	34.00 c.c.	68.00 c.c.	63.00 c.c.
Volatile acids	2.68 "	2.50 "	3.50 "	3.50 "
Fixed organic acids	4.38 "	3.38 "	7.75 "	8.75 "
Primary phosphates	32 30 "	29.50 "	60.50 "	52.25 "
Corresponding P_2O_5	0.229 g.	0.2095 g.	0.4296 g.	0.371 g.
Total P_2O_5	0.534 "	0.469 "	0.819 "	0.782 "

Amount of 0.1 normal soda solution required for 100 g. dry matter:

Total acidity	66.43 c.c.	62.35 c.c.	82.31 c.c.	70.91 c.c.
Volatile acids	4.63 "	4.58 "	4.24 "	3.94 "
Fixed organic acids	7.71 "	6.20 "	9.38 "	9.85 "
Primary phosphates	56.80 "	54.10 "	73.24 "	58.81 "
Corresponding P_2O_5	0.403 g.	0.384 g.	0.520 g.	0.418 g.
Total P_2O_5	0.941 "	0.860 "	0.993 "	0.880 "

ACIDITY OF MALT ON KILN (PRIOR).

Number of c.c. 0.1 normal soda solution per 100 g.	Bavarian Barley.			Bohemian Barley.		
	Air-Dried Malt.	Malt at 50° R. on Kiln.	Kiln-Dried Malt.	Air-Dried Malt.	Malt at 50° R. on Kiln.	Kiln-Dried Malt.
Water	17.39	3.81	2.91	11.15	3 68	2.19
Total acidity	68.00	79.5	78 5	63.00	72.50	73.00
Volatile acid	3.50	5.0	4.25	3.50	3.75	4.25
Fixed organic acid	7.75	10.0	9 5	8 75	8.50	8 25
Primary phosphate	60.5	66.5	67.8	52.25	64.00	63.75
Corresponding P_2O_5	0.4296	0.4722	0.4810	0.371	0.454	0.453
Total P_2O_5 quantitatively	0 819	0 865	0.863	0.782	0.901	0.885
Number of c.c. 0 1 normal soda solution per 100 g. dry matter.						
Total acidity	82 31	82.55	80 85	70.91	75 27	74.63
Volatile acids	4 24	5.19	4.38	3.94	3.75	4 35
Fixed organic acids	9 38	10.38	9.78	9.85	8.82	8.43
Primary phosphate	73.24	69.04	69 78	58.81	66.45	65.18
Corresponding P_2O_5	0.520	0.490	0.495	0.418	0.472	0.463
Total P_2O_5 quantitatively	0.993	0 898	0.889	0 880	0.935	0.905

The acidity of the malt from Bavarian barley taken from the kiln at 50° R. (144.5° F.) did not change during kiln-drying. On the other hand, there seems to be an increase in the amount of fixed organic acids and a corresponding decrease in the amount of primary phosphates. In the malt from Bohemian barley there is *an undoubted increase in the total acidity produced by the generation of primary phosphates in consequence of the formation of fixed organic acids.* These differences can be explained by the

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fact that the formation of acids is dependent, in a measure, on the amounts of moisture at different temperatures until 50° R. (144.5° F.) is reached, so that malt need only be held a little longer in a moist condition at 40° R. (122° F.), the optimum temperature for the lactic acid ferment. The malt dried according to the Bavarian system contains, therefore, a somewhat lower acidity than the other, which shows that at temperatures above 50° R. (144.5° F.) acid formation is checked, and that the generation of acids in malt is a consequence of the activity of the acid bacteria in the grown malt.

LOSSES AND GAINS IN STORING AND MALTING BARLEY.

Aside from such losses as are due to accidental causes, like the depredations of animals and insects (rats and weevils, for instance) the weight and volume of barley undergo certain changes during storage and malting which vary according to circumstances. These changes in weight and in volume, with the exception of those due to the removal of extraneous matter in cleaning, stand in very little relation to one another, since there may be a large loss in substance without a corresponding loss in volume during storage and malting.

LOSS THROUGH EVAPORATION.

The freshly harvested barley loses quite a large amount of moisture after being brought into the storage rooms and bins, its weight decreasing according to the percentage of moisture in the barley and atmospheric conditions as to dampness and temperature. The loss in weight may be as high as 5 per cent in a few weeks, when the barley contains a high percentage of moisture and is stored in a dry and warm room, while a comparatively dry barley may, on the other hand, increase in weight in a humid, warm atmosphere.

LOSS OF SUBSTANCE.

During storage there is also a constant loss due to giving off carbonic acid, indicating a process of respiration going on in the corn, and the amount of starch and of albuminoids is consequently diminished.

This respiration is accompanied by the development of heat in consequence of which the temperature of the barley rises at times to such an extent as seriously to injure the barley. There

fore, the barley must be watched and cooled by turning or moving if a rise in temperature is noticed. The more moisture the barley contains (freshly harvested barley, for instance) the quicker will the temperature rise, the oftener must the heap be turned.

Barley loses its germinability gradually during storage, and the loss in this respect is the more rapid, the more moisture the barley contains. Under ordinary circumstances 5 to 10 per cent of the germs will cease to develop after one year's storage of the barley, and after about five years all the germs have lost their vitality. If barley is dried, however, so that the moisture is reduced to about 10 per cent, the germs are not so readily affected.

According to Haberlandt (Thausing, 1898, page 337) the percentages of germs of barley containing various amounts of moisture, that germinated after different storage periods, are as follows:

Per cent of germs grown.	Per cent of moisture in barley.	Period of storage.
91 per cent	12.08 per cent	2 years.
22 per cent	12.08 per cent	7 years.
96 per cent	9.06 per cent	2 years.
86 per cent	9.06 per cent	7 years.

The changes in volume, due to storage of barley, do not fluctuate so much as those in weight, some American maltsters finding them to amount to less than 1 per cent, others regarding them as entirely insignificant.

In Germany the losses in volume are regularly determined in some localities. According to observations of Prussian grain inspectors this loss amounts: During the first three months after harvesting to 1.3 per cent; second, 0.9 per cent; third, 0.5 per cent; fourth, 0.3 per cent; and may be figured at 1/4 per cent for each succeeding year (Thausing, 1898).

SHRINKAGE OF BARLEY DUE TO CLEANING.

According to information furnished by American malting plants operating on a large scale, the shrinkage, or losses, due to the removal of foreign matter, broken or undersized corns, etc., during preliminary cleaning by blower and sifter, amounted

to the following percentages, dependent upon the quality and kind of the barley:

	1899.	1900.
Dakota barley No. 2..................	2 per cent	4 per cent
Canada barley No. 1..................	1 per cent	3 per cent
Canada barley No. 2..................	2 per cent	4 per cent
Wisconsin, Minnesota, Iowa No. 1....	1 per cent	3 per cent
Wisconsin, Minnesota, Iowa No. 2....	2 per cent	4 per cent
Wisconsin, Minnesota, Iowa No 3....	4 per cent	6 per cent

The loss in final cleaning and grading by blower and needle machine amounted to 5 per cent in 1900 barley, while 1899 barley gave only 3½ to 4 per cent.

The loss in skimming was:

	1899.	1900.
Wisconsin, Minnesota, Iowa No. 1....	2 per cent	3 per cent
Wisconsin, Minnesota, Iowa No. 2....	3 per cent	5 per cent
Wisconsin, Minnesota, Iowa No. 3....	5 per cent	7 per cent

The barley crop of 1900 was abnormally poor in quality, while the crop of 1899 is to be considered as normal.

Average total shrinkage for 1900:

Wisconsin, Minnesota, Iowa No. 1................	10 per cent
Wisconsin, Minnesota, Iowa No. 2................	15 per cent
Wisconsin, Minnesota, Iowa No. 3................	17 per cent

For valuable information due to extensive tests made on American soil in this line, the brewing trade is indebted to C. Birkhofer. In order to ascertain the exact loss in weight entailed during the operations of cleaning, skimming, steeping, germinating, kiln-drying and finally of cleaning the malt, Mr. Birkhofer experimented with three kinds of barley, differing largely from each other in quality, arriving at the following results:

Thirty-eight thousand six hundred and fifty pounds (38,650) of heavy Wisconsin Scotch barley of excellent quality, 55 pounds bushel-weight and 10 per cent moisture, furnished 32,785 pounds of sprout-free malt, with 3 per cent of moisture. Consequently 100 pounds of barley would yield 84.8 pounds sprout-free, kiln dried malt. The ungerminated kernels amounted to about 2 per cent. The total loss amounted to 5,865 pounds = 15.2 per cent, which was distributed as follows:

Loss in cleaning........................	200 pounds	0.52 per cent
Skimmings	50 pounds	0.13 per cent
Sprouts	1,100 pounds	2.87 per cent
Moisture	2,757 pounds	7.1 per cent
	4,107 pounds	10.62 per cent

The difference between the total loss and the above summary is equal to 5,865 — 4,107 = 1,758 pounds, or 4.6 per cent. This figure represents the loss in weight of the barley through extraction of substance during steeping and by exhalation of gaseous products during germination (carbonic acid). The absorption of moisture by the fresh kiln-dry malt during two months' storage amounted to 3 per cent. A hundred parts of barley, consequently, furnished 84.8 + 2.5 = 87.3 per cent of stored malt with 6 per cent moisture.

From 132,900 pounds No. 3 (Chicago grading) Minnesota barley with a bushel-weight of 50.5 pounds and 11 per cent moisture there were obtained 104,200 pounds sprout-free, kiln-dried malt with 3 per cent moisture. Consequently 100 pounds of barley would give 78.4 kiln-dried malt. The number of ungerminated grains amounted to 5 per cent. The total loss of substance reached 28,700 pounds = 21.6 per cent, and was distributed among the different stages as follows:

Loss during cleaning..............	1,730 pounds	1.3 per cent
Skimmings	3,720 pounds	2.8 per cent
Sprouts	3,854 pounds	2.9 per cent
Moisture	10,893 pounds	8.0 per cent
	20,197 pounds	15 per cent

The loss in steeping and germination (exhalation of carbonic acid) was 8,503 pounds = 6.35 per cent. The absorption of moisture during two months' storage amounted to 3 per cent. Consequently 100 parts of barley gave 78.4 + 2.4 = 80.8 parts of stored malt with 6 per cent moisture.

A lot of 71,700 pounds No. 4 Dakota barley, very light in weight, considerably damaged by rain, with a bushel-weight of 47 pounds, and 11 per cent moisture, furnished 54,080 pounds kiln-dry malt with 3 per cent moisture. Consequently 100 parts of barley furnished 75.4 parts of sprout-free, kiln-dry malt. The ungerminated grains were 8 per cent. The total loss of sub-

stance amounted to 17,620 pounds = 24.6 per cent, and was distributed as follows:

Loss in cleaning..................	1,716 pounds	2.40 per cent
Skimmings	3,206 pounds	4.47 per cent
Sprouts...........................	2,294 pounds	3.20 per cent
Moisture	5,535 pounds	7.70 per cent
	12,751 pounds	17.77 per cent
Loss in steeping and germinating.	4,869 pounds	6.8 per cent

Consequently 100 parts of barley furnished 75.4 + 2.6 = 78 parts of stored malt with 6.3 per cent moisture. In nine experiments recorded by the same author the following maxima and minima were determined:

	Maximum.	Minimum.
Bushel weight of barley in pounds.......	55	46.5
Bushel weight of kiln-dry malt in pounds.	37	32.5
Weight of sprouts from 100 pounds barley in pounds	3.2	2.8
Loss of cleaning and skimming from 100 pounds of barley..................	6.9	0.65
Loss in steeping and germinating........	6.8	4.6
Total loss of substance..................	24.6	15.2
Barley used for the production of 100 pounds kiln-dry malt...............	133.0	118.0
Barley used for the production of 100 pounds stored malt	128.0	114.0

The following table will show at a glance the differentiation of barley and malt, according to the above tests:

COMPARISON OF BARLEY AND MALT.

	Wisconsin Scotch Barley.	Minnesota. No. 3.	Dakota. No. 4.
Bushelweight..............................	55 lbs.	50 5 lbs.	47 lbs.
Length of radicles........................	1¼ %	1¼ %	1¼ %
Kernels not grown	2 %	5 %	8 %
Length of acrospire	¾ %	¾ %	¾ %
Amount of moisture in malt from kiln....	3 %	3 %	3 %
Loss in cleaning....	0.52 %	1.3 %	2.4 %
Loss in skimming............	0.13 %	2.8 %	4.47 %
Loss in sprouts......	2.87 %	2.9 %	3.2 %
Loss of extract as food for germs..........	4.6 %	6.35 %	6 8 %
Loss on kiln, moisture......	7.1 %	8.0 %	7.7 %
From 100 lbs. of barley was obtained malt fresh from kiln with 3% moisture..	84 08 lbs.	78.40 lbs.	75.81 lbs.
Malt after 2 months storage 6% moisture..	87.3 "	80.8 "	78 "

MALT INCREASE.

Barley and malt are bought and sold in America by weight, but in terms of bushels—a bushel of barley agreed to represent 48 pounds, a bushel of uncleaned malt, 34 pounds, a bushel of cleaned malt, 33 pounds. Since the loss in weight from cleaned barley to malt does not amount to so much as the difference between the bushel-weight of barley and that of malt, the maltster obtains a greater number of bushels of malt than he has put bushels of barley into his steeping tank. Thus 38,450 pounds of Wisconsin barley cleaned, or $38{,}450 \div 48 = 801$ bushels, yielded 32,785 pounds, or $32{,}785 \div 33 = 993\frac{1}{2}$ bushels of malt fresh from the kiln, germ-free, which represents an increase of $993\frac{1}{2} - 801$ or $190\frac{1}{2}$ bushels, or $190\frac{1}{2} \times 100 \div 801$ per cent $= 24$ per cent.

This was an exceptionally heavy barley with little loss in skimmings. Ordinarily, the increase is much less. In case of the Minnesota barley the figures would be as follows:

One hundred and thirty-one thousand one hundred and seventy (131,170) pounds cleaned No. 3 (Chicago grading) Minnesota barley or $131{,}170 \div 48 = 2{,}732$ bushels gave 104,200 pounds, or $104{,}200 \div 33 = 3{,}157.6$ bushels of malt fresh from kiln and germ-free, an increase of $3{,}157.6 - 2{,}732 = 425.6$ bushels, or $425.6 \times 100 \div 2{,}769 = 15\frac{1}{2}$ per cent, which increase may be considered the average.

From figures obtained in malting establishments operating on a large scale the increase was found to be for:

	1899.	1900.
Dakota barley No. 2......	18 — 19 per cent	.... per cent
Canada No. 1............	19 — 20 per cent	.... per cent
Wisconsin No. 1, Minnesota No. 1, Iowa No. 1....	17 — 18 per cent	15 — 16 per cent
Wisconsin No. 2, Minnesota No. 2, Iowa No. 2....	15 — 16 per cent	14 — 15 per cent
Wisconsin No. 3, Minnesota No. 3, Iowa No. 3....	14 — 15 per cent	12 — 13 per cent

The increase becomes still greater if the weight of the finished malt is compared with the malt that actually undergoes *the malting* process, that is, deducting the weight of the skimmings *from the* cleaned barley, and if the barley is compared

[redacted]

with stored malt after it has taken up some moisture. Generally speaking the increase is greater for two-row than for six-row barley; larger for a better grade of barley; larger for a poorly-grown than for a well-grown malt; larger after storing, and larger for a poorly stored than for a well stored malt, and the amount of increase is really without much significance on the whole.

LOSS IN VALUE THROUGH ABSORPTION OF MOISTURE.

When malt is poorly stored the brewer, since he buys the malt by weight, and pays for the moisture the malt absorbs during storage, is the loser. One hundred pounds of malt will yield the smaller an amount of extract or wort of a certain gravity, the larger is the amount of moisture it contains. It is apparent that when 100 pounds of malt have absorbed 3 pounds of moisture it will take just 103 pounds of malt to get the same amount of extract or wort as before. For a brew of 100 barrels, for which, say 5,000 pounds of malt is employed, this would mean a loss for the brewer of $(5{,}000 \div 100) \times 3 = 150$ pounds, or over four bushels of malt.

The malt will always take up moisture in transit, and consequently the brewer should receive a larger amount of malt in weight than was consigned to him.

LOSSES AND GAINS IN MALTING IN GERMANY.

It will be quite instructive to compare the data about American barley and malt with results obtained by German observers concerning German malt and barley. Thausing, for instance, states that the loss by germination is quite uniform, amounting to about 8.5 per cent on an average (C. Birkhofer's results give an average of about 8.9 per cent), from which about 3 per cent have to be deducted for the formation of sprouts (C. Birkhofer's average being 2.99 per cent), and about 5.5 per cent are consumed in germination (C. Birkhofer does not specify this loss in each case separately). Other elements determining the total loss, for instance, the quantity of moisture and foreign admixtures, vary considerably, according to the origin of the barley and other conditions. Well cleaned barley with 86 per cent of dry substance furnishes for each 100 pounds of barley.

Well steeped barley .... 141.1 pounds
Green malt .... 134.2 pounds

Malt and sprouts (dry substance)	79.7 pounds
Fresh malt (germs included)	81.3 pounds
Sprouts	4.0 pounds
Dry substance of malt	75.0 pounds
Fresh degerminated malt with 2 per cent moisture.	77.3 pounds
Stored malt with 5 per cent moisture	79.5 pounds

Twelve per cent of the original weight of the dry barley substance was lost, namely, in steeping 1.5 per cent, substances gasified during germination 6 per cent, sprouts 4.5 per cent. Following are results of actual, very numerous observations in German malt houses on air-dry barley. One hundred parts of cleaned barley will give:

	From	To	Average.
Loss from skimmings	0.8 per ct.	2.0 per ct.	1.2 per ct.
Well steeped barley	135.0 per ct.	160.0 per ct.	148.0 per ct.
Green malt (fresh)	135.0 per ct.	148.0 per ct.	140.0 per ct.
Kiln-dry malt freshly cleaned	73.0 per ct.	78.0 per ct.	76.0 per ct.
Stored malt	75.0 per ct.	80.0 per ct.	78.0 per ct.
Sprouts	3.5 per ct.	4.8 per ct.	4.0 per ct.

Allowance, of course, must be made for the difference in the quality of the barley. As a rule, however, the difference between the weight of the barley and the malt is the greater, the larger the growth of malt on the floor proved to be. For fresh kiln-dried cleaned malt it amounts to 23 to 25 per cent, and stored malt 21 to 23 per cent of the weight of the barley.

E. L. Hartmann determining the changes in weight and volume that German barley undergoes in the malting process, arrived at the following results, based upon years of practical experience (Zeitschrift f. d. ges. Brauwesen, 1895, p. 148):

CHANGES IN GERMAN BARLEY BY MALTING.

	Maximum		Minimum		Average	
	Weight.	Volume.	Weight.	Volume.	Weight	Volume.
Barley charged into steep	100.	100.	100.	100.	100.	100.
Steeped barley	162.21	160.42	133.08	122.53	148.78	145.49
Green malt	151.73	268.57	130.98	200.00	133.43	227.44
Polished kiln-dried malt	80.44	108.51	72.05	92.40	76.57	101.32
Malt sprouts	4.76	21.50	2.08	8.10	3.63	13.06

Prior found by similar tests that the loss in weight from barley to kiln-dried malt (Bavarian) amounts to 26.2 to 30.5 per cent (Bayerisches Brauerjournal, III, p. 157).

Schütt found that during a 9 days' germinating period for German malt, 100 parts of malt, figured on a dry basis, generated 10.9 parts of carbonic acid by weight, which was obtained from 6.7 parts of starch (Wochenschrift f. Brauerei, 1887, p. 673). At the same time 3.7 parts by weight of water was formed from which results Thausing computes that 0.4 parts of fat and 6.0 parts of starch were consumed. The heat produced during this period amounted to 285.40 calories or heat units.

CHANGES IN COMPOSITION OF WORT FROM MALT AFTER SEVEN MONTHS' STORAGE (AUBRY).

		Fresh.	Stored.
In dry matter of malt.	Extract	77.91	77.72
	Maltose	54.83	50.07
	Nitrogen	0.623	0.489
	or Albumen	3.90	3.06
In extract	Maltose	69.38	64.44
	Nitrogen	0.800	0.630
	or Albumen	5.00	......
	Maltose to Non-Maltose = 1 to	0.42	0.55

INSECT PESTS IN GRANARIES.

The increased facilities of exchange of products between the different parts of the globe, made possible by rapid transportation, have not been without drawbacks. The English sparrow in the United States, and the rabbit in Australia are not the only examples of unfortunate exchanges between different countries. Less obtrusive but capable of doing an immense harm to vegetation is the insect-pest which commerce has carried, with grain and other food-products, to all parts of the globe. Most of these insects, which are found indoors in the northern part of the United States, are natives of tropical countries and do not, therefore, thrive so well in the colder climate. It is in the southern states, where they have found a new and congenial home, that they do the greatest harm outdoors while in the northern states they become especially dangerous to the grain in the granaries or elevators.

The damage done by insects to stored grain in Texas alone has been estimated at over a million dollars a year, and in Alabama in 1873 the loss to the corn crop was estimated at $1,671,-382, or about 10 per cent, according to Assistant Entomologist

Chittenden in "Some Insects Injurious to Grain," U. S. Department of Agriculture, Farmers' Bulletin No. 45, which has been our main source of information.

The different grains offer more or less resistance to the attack of the insects, the softer ones naturally falling an easier prey to the ravages than the hard flinty ones; unhusked oats are almost exempt, whereas the hull of barley offers but little resistance.

Heat and dampness are highly favorable to insect life, but the idea that such conditions will produce insects is wrong, and each individual insect owes its existence to an egg deposited in the grain.

A large number of insects in a heap of grain sometimes cause a rise of temperature, probably on account of chemical changes in the excreted matter.

The grain-damaging insects may, for our purpose, be divided into two classes, namely:

Class I.—Such insects as attack whole grain.

The most important of these are:

The *Granary Weevil;*

The *Rice Weevil,* and

The *Grain Moths.*

Class II.—Such insects as attack grain products and are therefore commonly found in flour mills, but may also be dangerous to whole grain.

The most dangerous of these are:

The *Mediterranean Flour Moth.*

The *Indian Meal Moth.*

The *Confused Flour Beetle.*

The *Saw-toothed Grain Beetle.*

The *Cadelle.*

CLASS I.—INSECTS THAT ATTACK THE WHOLE GRAIN.

Weevils are a very large group of beetles. They are easily distinguished by their peculiarly shaped head, which is extended into a long snout, toward the end of which the short, usually elbowed, antennæ project on each side. Most insects which feed on stored grain are called weevils, but the only true weevils of the granary are the two mentioned above: the granary weevil and the rice weevil. In appearance they resemble each other very much.

[redacted]

The illustrations show the insects enlarged, the actual size being indicated by lines accompanying the figures.

Granary Weevil (*Calandra granaria*).—This old enemy of stored grain has from time immemorial led an easy life and in consequence lost the use of its wings. When fully developed it measures from one-eighth to one-sixth of an inch, and is of a bright chestnut brown color. The larvæ are short, fleshy, legless grubs, shorter than the adults, with a series of tubercles along each side of the body; the head is round with strong jaws (see

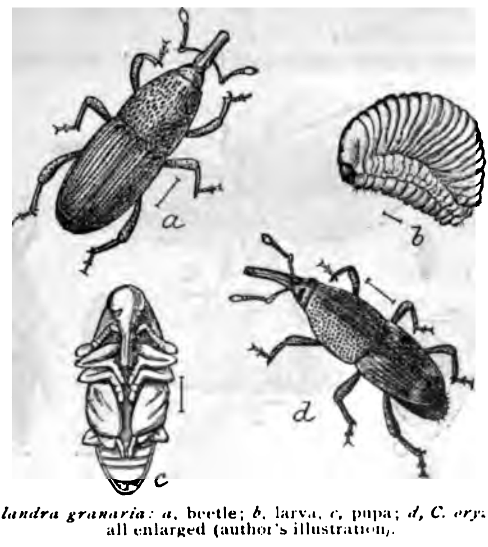


Fig. 1—*Calandra granaria*: *a*, beetle; *b*, larva, *c*, pupa; *d*, *C. oryzae*, beetle—all enlarged (author's illustration).

Fig. 1). The pupa is white, clear and transparent, showing the forms of the future beetle.

The female bores a hole in the grain with her snout and deposits an egg. The larva, when hatched, lives on the contents of the kernel and undergoes its changes within the hull.

The time required for the change from egg to fully developed beetle depends on the temperature. In the northern states there may be four to five generations, and in the south six to seven, or even more, and one pair may in one year produce 6,000 descendants.

Barley as well as wheat, maize and other grains are attacked by this beetle.

Rice Weevil (*Calandra oryzae*).—As its name indicates it was first found in rice, and is supposed to have come from India. It is found in every state, but is of small importance in the north. In size and appearance it is similar to the granary weevil, but its color is more of a dull brown, with four faint red spots on the wing cases, has well developed wings and can fly. The rice weevil is therefore often found in the field. It feeds on rice, wheat, maize, barley, rye, hulled oats, and when abundant attacks also barrels of flour and bags of meal.

Grain Moths (*Sitotroga cerealella*).—The Angoumois Grain

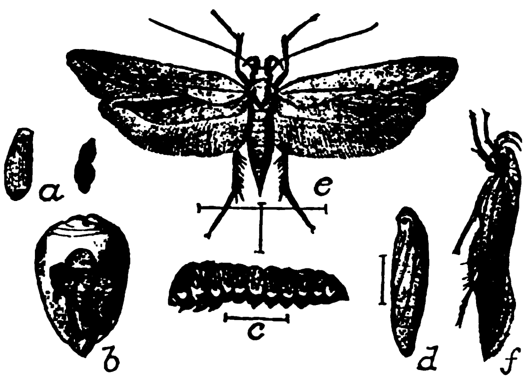


Fig. 2—*Sitotroga cerealella*: *a*, eggs; *b*, larva at work; *c*, larva, side view; *d*, pupa; *e*, moth; *f*, same, side view (original).

Moth (so-called from the province of Angoumois in France), or the Fly Weevil, as it is incorrectly called in this country, has spread from North Carolina and Virginia into the southern states, where its ravages are enormous. It is also found in the southern part of the northern states. Though not so widely distributed as the weevils, it threatens to become an even more serious danger. It infests all cereals, and it has been estimated that grain infested by this moth may lose 40 per cent in weight and 75 per cent of its mealy matter.

The adult insect resembles to a great extent a clothes moth, *is of grayish brown* color, slightly spotted with black, and meas-

ures about half an inch across the expanded fore-wings. The hind-wings are bordered with a long delicate fringe.

The eggs when first laid are white, but soon turn red. The moth deposits its eggs in standing grain, or in the bin, singly or in clusters of 20 to 30. A small grain suffices for one individual, but in large kernels, as of maize, may be found two or more

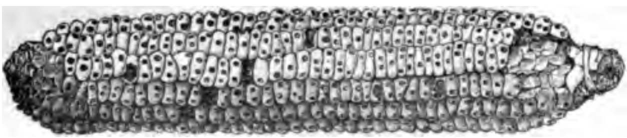


Fig. 3—Ear of pop-corn showing work of Angoumois grain moth (from Riley in Ann. Dept. Agr. 1884).

caterpillars in each. An ear of infected pop-corn is shown in Fig. 3. In the warm climate of the southern states as many as eight generations may be produced every year.

CLASS II.—INSECTS THAT ATTACK CHIEFLY GRAIN PRODUCTS.

Insects that may damage stored grain, but are more frequently found in mill products.

Mediterranean Flour Moth (*Ephestia kuehniella*).—This insect

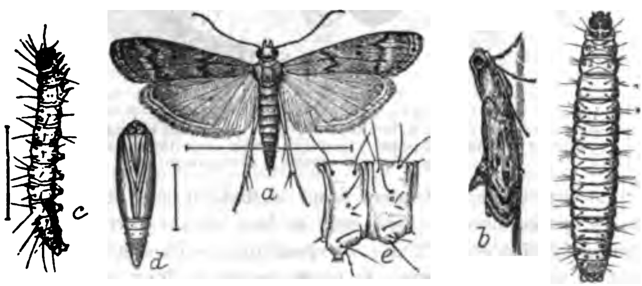


Fig. 4—*Ephestia kuehniella*: *a*, moth; *b*, same from side, resting; *c*, larva; *d*, pupa—enlarged; *e*, abdominal joint of larva—more enlarged. Larva, dorsal view (original).

is the scourge of the flour mill, and was first noticed in a flour mill in Germany in the year 1877. England was invaded in 1886, and three years later the insect had found its way to Canada. In 1892 it was heard from in California and in 1895 the mills of New York and Pennsylvania were infected by it. In fact, it

rapidly spreading throughout the civilized world, and its hold on Canada indicates that the insect is capable of indoor existence in a colder climate than most other grain insects.

The adult moth has a wing-expanse of a little less than an inch, the fore-wings are leaden gray with black markings, the hind-wings are of a dirty white, with a darker border. The caterpillars are white and hairy, and spin around them a web in the form of a cylinder. When ready to undergo its transformation the grub leaves its silken house, and wanders around in search of a proper place, spinning its web all the time, causing the flour to felt together and become lumpy.

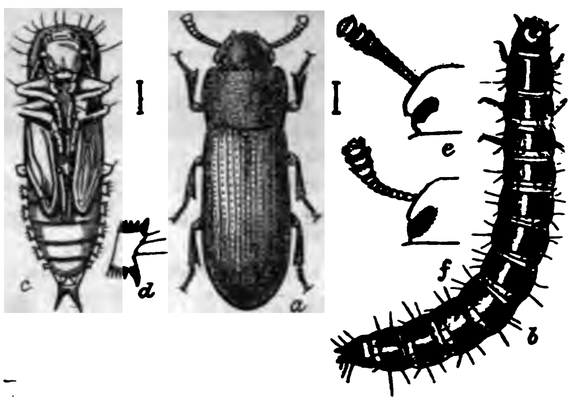


Fig. 5—*Tribolium confusum*: *a*, beetle; *b*, larva; *c*, pupa—all enlarged; *d*, lateral lobe of abdomen of pupa; *e*, head of beetle showing antenna; all greatly enlarged (author's illustration).

Although the larva prefers flour or meal it will attack grain, bran, prepared cereal foods, etc., in lack of the former.

Indian Meal Moth (*Plodia interpunctilla*).—This insect is often found in mills and stores. It feeds on meal, flour, bran, grain, dried fruit, etc. The adult measures across the expanded wings from one-half to three-fourths of an inch. The fore-wings are, nearest the body, of a dirty gray, the outer two-thirds of a reddish brown.

Confused Flour Beetle (*Tribolium confusum*).—This beetle is nearly of the same size as the grain-weevil with which it is often found together. The grown beetle is about one-sixth of an inch

long, brown in color, and flattened. It had long been known in Europe, when in the fall of 1893 it was recognized in this country. In less than two years from its first appearance it had, however, been reported from every state, and caused more complaints than any other grain-devouring pest.

Saw-Toothed Grain Beetle (*Silvanus surinamensis*).—This beetle is only one-tenth of an inch long, slender and flat, and of a chocolate-brown color. The thorax (the part of body next the head) has six saw-like teeth on each side, and two shallow grooves on the upper side.

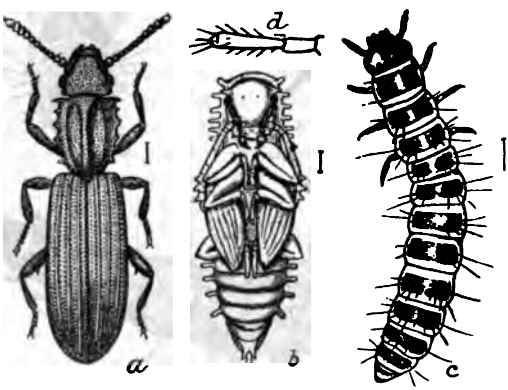


Fig. 6 -*Silvanus surinamensis*: *a*, adult beetle; *b*, pupa; *c*, larva—all enlarged; *d*, antenna of larva, still more enlarged (author's illustration).

The larva is almost white, has six legs and is very active, running about and nibbling here and there. When ready to undergo its transformation, it builds a covering of small grains or particles of food, gluing them together with an adhesive substance, secreted from its body. There may be four to six generations. This grain-beetle is found in nearly all granaries and places where edibles are stored.

Though it usually follows the attack of other insects (especially the Indian Meal Moth), it does considerable damage, being nearly omnivorous.

Cadelle (*Tenebroides mauritanicus*).—This beetle is as widely distributed as any of the preceding species, but, happily, it is not so prolific, producing only one generation annually. There has

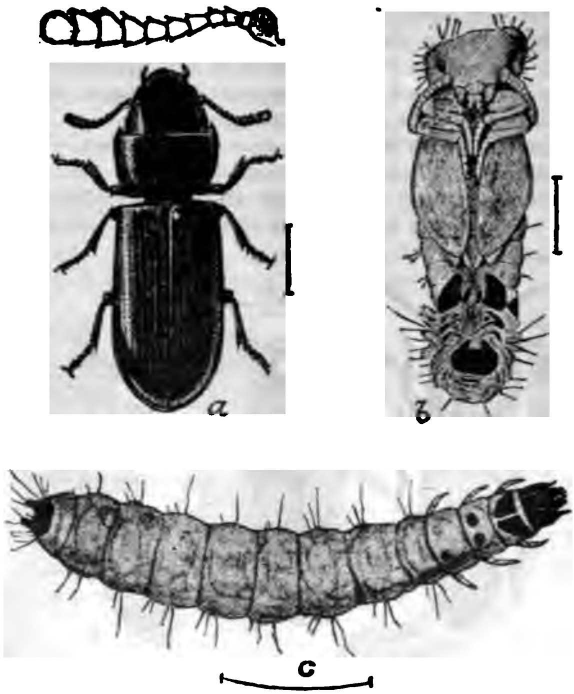


Fig. 7.—*Tenebroides mauritanicus*: *a*, adult beetle with greatly enlarged antenna above; *b*, pupa; *c*, larva—all enlarged (author's illustration).

been a dispute about the grain-eating propensities of this insect, but experiments by Mr. F. H. Chittenden have conclusively proved that it feeds upon grain both in the larval and adult conditions, going from kernel to kernel, devouring the germ only, and destroying the grain for germinating purposes. Both larva and beetle partly repay the damage by destroying all other grain insects that they encounter.

PREVENTION AND DESTRUCTION.

Prolific as weevils are and in a still higher degree the moths, a few individuals of a species would in a year develop into countless numbers, were it not that nature itself checked the increase. The grain insects are themselves preyed upon by other creatures,

spiders in the mills, birds and bats in the field are steadily pursuing them.

Nor are the grain-feeding insects free from parasitic enemies, and a case is known where the Mediterranean Flour Moth was destroyed by the introduction of a parasite. Nevertheless, man's own ingenuity must take up the fight against the evil, if he desires to keep it under control.

Much can be done to prevent the introduction into the granary of the insect-pest by harvesting as early as possible, and by letting the threshing follow as soon as can be arranged. Many insects are killed during the threshing by the agitation of the grain, and are blown away with the chaff, but the eggs and larvæ concealed in the seeds pass through the threshing operation safely.

Further means of treating the fresh grains are, therefore, necessary. The appearance of the Mediterranean Flour Moth on the Pacific Coast has caused the introduction of a so-called quarantine bin in which suspected grain can be fumigated. This bin should be as air-tight as possible.

Fresh grain should not be placed in bins holding weeviled grain. Before storing the new grain, the bins should be thoroughly cleaned; floors, walls, ceilings, brushed and scrubbed; no refuse materials, such as sweepings of grain should be allowed to accumulate; the floors should be swept frequently, and all rubbish burned. The floors, walls and ceilings should be smooth, so as not to afford any lurking places for the insects, and a coat of oil painting or white-washing gives further security.

As the "heating" of grain is highly favorable to the development of weevils, no artificial heat should be employed in a grain storage building. A cool and dry place, that can be thoroughly aired, is the ideal repository of grain.

Storage in bulk, and frequent agitation of the grain is destructive to moths, as they are unable to extricate themselves from under a large mass of grain. Against weevils bulking is also of value, but stirring would only distribute them more completely.

A temperature of 125° to 140° F. for a few hours will kill the insects in the grain, and kiln-drying at a still lower temperature has also been found effective.

A low temperature is also fatal, and by stirring the grain, or by filling the building with steam and then opening the windows and exposing the insects to frost they may be successfully dealt with.

CHEMICAL MEANS OF DESTROYING THE INSECTS.

Many remedies have been proposed, and few have been found practical. A most powerful preservative is naphthaline, and for seed-stock in air-tight receptacles it is almost perfect. Its strong and permanent odor excludes its use for food products.

Steam has been successfully used against the flour moth, and also for disinfecting bags and machinery in the quarantine box. Sulphur alone and sulphur and steam, as well as benzine and naphtha have been used, but they have either certain disadvantages or are not quite effective.

Bisulphide of carbon has been found the cheapest, simplest and most effective insect killer. It is a colorless fluid, highly inflammable, evaporates rapidly at ordinary temperatures, and is very poisonous. It may be sprinkled over the grain or, which is a more effective way, may be allowed to evaporate from shallow dishes or on cotton waste in bins that are somewhat air-tight or partly made so by being covered with canvas or blankets. The fumes being heavier than air, sink through the mass of the grain, destroying everything in the form of insects or vermin.

The quantity of bisulphide needed depends on the tightness of the bins, usually 1 to 1½ pounds is calculated per ton of grain. Twenty-four hours fuming is usually sufficient, but even an exposure of 36 hours will not impair the germinating power of the grain.

A good time for such a fuming is during daylight on a Saturday afternoon, closing the doors and windows as tight as possible and preventing any one from entering. The fuming should begin in the lowest story to escape the effect of the settling gas. Next Monday morning the building should be thoroughly aired and the grain stirred.

Though the vapor of the bisulphide is deadly to all forms of animal life, a small amount will not produce any evil effect, but being highly inflammable no fire or lighted cigar must be brought into the building until the fumes have been carried away.

The bisulphide treatment cannot be used for malt infested by insects on account of the offensive odor it would impart. Here redrying in kiln would seem to be the most practical mode of destruction or, if this is impracticable, fumigating with sulphur or chlorine (chloride of lime).

BREWERY OUTFIT.

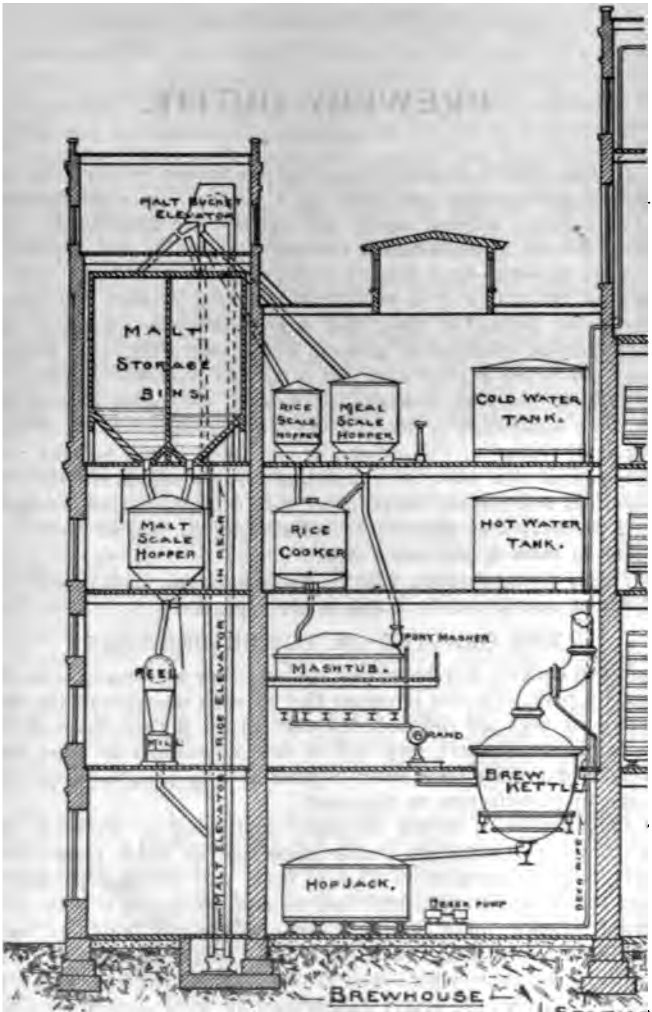
In this chapter is given a general description of the most approved arrangement and outfit of a modern American brewery. It goes almost without saying that any detailed description of the great variety of implements, machines, apparatus and appliances that go to make up a modern brewery outfit would not only be beyond the design of a pocketbook like the present, but would occupy an amount of space that is prohibitory in a work of this size. Being confined to general terms, therefore, this chapter may not afford a great deal that is new to brewers. In order to round out the plan, however, of treating the entire field of the brewing industry, it is necessary to give a comprehensive, though succinct, review of this branch of the subject, and persons who may consult this book in libraries, newspaper offices, scientific institutions and similar places, other than breweries or malt-houses, will probably find answers to most questions that are likely to occur to them in this connection.

Tables giving accurate relative dimensions and capacities of the different vessels will be found in the appendix.

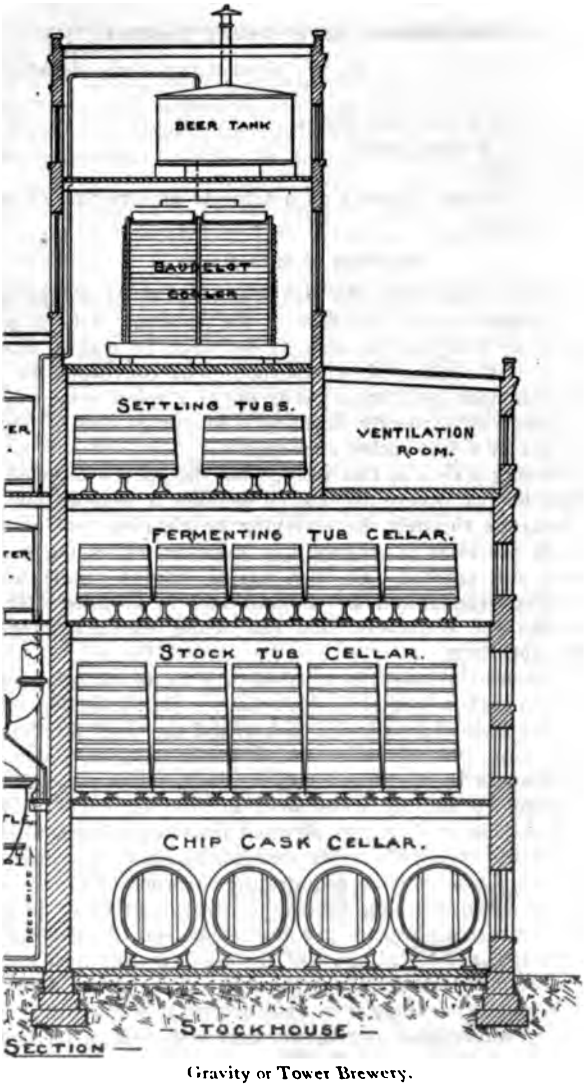
THE GRAVITY OR TOWER BREWERY.

When entirely new breweries are built they are arranged on the gravity plan. By this is meant that in each department the materials or beer are elevated but once to the highest floor of the building, from where they fall or flow downward by their own weight or gravity from floor to floor as they progress from one stage of manufacture to the next.

This implies a saving of power and labor by avoiding the relifting or repumping usually necessary in older plants that have been enlarged from time to time, and where departments that should be situated above one another are placed side by side, and frequently quite far apart, because the old buildings were too weak or the plant too busy to allow proper remodeling. Instances are known where such faulty arrangement has caused as much as double the yearly expenditure in some departments for power or labor of what would be required by a modern plant of equal yearly output.



Gravity or Tower Brewery.



Gravity or Tower Brewery.

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DEPARTMENTS OF A GRAVITY BREWERY.

Modern breweries are usually divided into three departments, viz.:

1. The elevator or mill house.
2. The brew-house and
3. The cellars.

Each department operates on a separate gravity plan of transfer of materials.

ELEVATOR OR MILL HOUSE.

In the first department, the malt is elevated to its storage bin or hopper, situated on the top floor of the building. This is generally done by dumping the malt, if delivered by wagon, down a chute or, if the plant has a malt-house, by conveying the malt across from such malt-house by means of a spiral conveyor, and in both cases subsequently elevating it to storage bins or hoppers by the use of a belt-bucket conveyor.

By opening a slide in this storage bin the malt is dropped into the scale hopper, where the desired quantity is weighed out, and then descends through the screening or cleaning reel into the malt mill, where it is crushed. In some breweries the malt is screened and crushed and then passes into the scale hopper where it is weighed and stored until used in brewing. Next it drops into the conveyor, thus completing the first stage of gravity operation.

The conveyor elevates the crushed malt to its storage hoppers, situated on the top floor of the brew-house. Of these hoppers, one is used for malt to go into the cooker, and the other for the malt which is to go into the mash tun. These hoppers are sometimes, for economy in building construction, placed under the malt mill, thus dispensing with the extra story in the brew-house, and the crushed malt is, in that case, elevated from these hoppers to the mashing outfit directly. In this arrangement, however, there is a possible drawback, as it necessitates the operation of the elevating machinery when mashing begins, for which all other preparations are made in advance, and any breakdown of elevating machinery, especially in case part of the crushed malt is already in the mash tub, might cause considerable inconvenience, delay and loss. With the arrangement first described the crushed malt *is elevated beforehand*, during the day, and once in its hopper, *descends by gravity* in all the succeeding operations.

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Raw cereals are sometimes elevated in bulk and stored in a hopper next to the malt storage hopper, then weighed in the same scale hopper, or in a separate one, and likewise elevated to a separate cereal hopper in the brew-house. Another method, however, which is quite frequently used is to hoist the raw cereal in the original sacks, either to the mill-house or the brew-house, and when wanted, to dump it down a chute leading into the cooker. As the sacks are generally of equal and known weight, they are merely counted and the desired amount calculated without weighing.

The water used in brewing is pumped into tanks or reservoirs situated on the top floor of the brew-house. If there are two of these floors above the mash tub, both cold and hot water tanks are usually placed upon the top floor, that is, on the floor above the cooker, but sometimes the hot water tank is placed on the floor below. Where there is only one of these top floors, that is, no floor above the cooker, as in the construction above mentioned, both tanks are sometimes placed on this one floor, although often the cold water tank is placed upon the roof in order to give a gravity supply of water to the cooker.

THE BREW-HOUSE.

The second gravity stage now commences; the raw cereal and part of the crushed malt from the hoppers, together with water from the cold water tank, descend into the cooker, to form the cereal mash. From the cooker, the cereal mash again descends into the mash tun, where it is added to the malt mash previously prepared from the remaining bulk of crushed malt in the hoppers and another quantity of water from the tanks.

The wort from this combined mash then flows by gravity into the kettle, the grains falling by gravity into the grain tank or wagon. Next the wort flows into the hop-jack, and finally into the wort pump, or lowest point in the brew-house.

THE CELLARS.

The wort is then pumped to the highest point in the cellars, namely, the surface cooler or beer tank, from which it begins the third gravity stage, flowing by successive stages of descent over the Boudelot cooler into the settling tubs, thence into the fermenting tubs and storage tanks, and finally into the chip *casks from which* it is racked off into trade packages.

BREW-HOUSE OUTFIT.

WAGON SCALES.

These are for weighing malt, cereals, etc., in bulk. They are generally situated outside of the office of the brewery, the indicator beam being placed inside. Wagon scales for breweries should have a capacity of 8,000 to 10,000 pounds. They should be extremely well taken care of, as inaccurate scales sometimes cause lengthy disputes and often considerable loss. The platform should be kept clean, and no dirt allowed to fall into the mechanism below. The balance should be adjusted as often as possible, in fact, before each weighing, and its accuracy tested from time to time.

ELEVATORS AND CONVEYORS.

These are constructed and operated in the same manner as those used in the malt-house. (See Malt-House Machinery.)

MALT STORAGE BINS.

Malt storage bins are made of either wood or steel. The sizes vary with the requirements of different plants up to 10,000 bushels' capacity.

Wooden bins are generally built of square shape, the large ones being mostly made of 2 x 6 inch pine boards, laid flat, that is, edges out, one on top of the other.

Steel bins are usually round, and, if very large, are stay-bolted to insure rigidity.

MALT AND CEREAL HOPPERS.

These are built either of sheet steel or iron (round or square), or of wood (square), and are used mostly where the malt for a few brewings only is brought in the brewery. These hoppers are provided with a conical bottom so as to insure complete emptying by gravity. They are closed at the cone bottom by a slide or gate, by opening and closing which any desired amount of malt can be discharged.

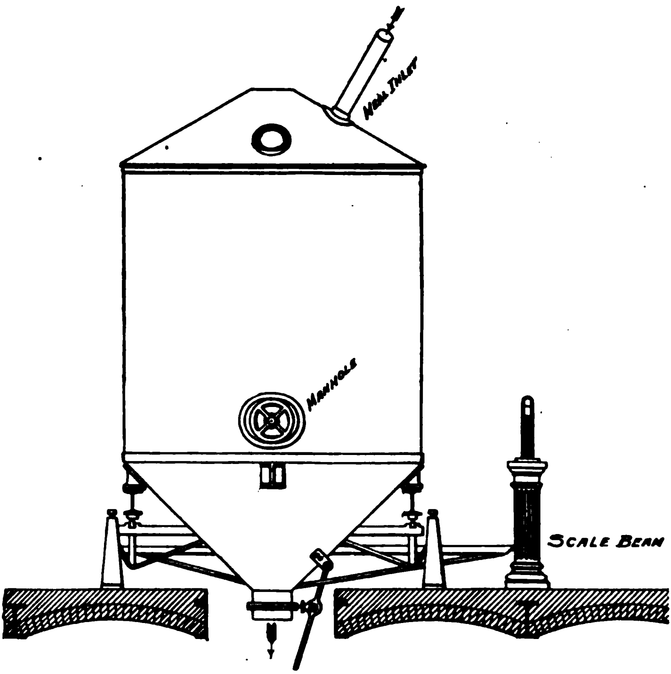
Cereal hoppers are also in general use, although the cereal is often handled in the original sacks as indicated in the general description of brewery arrangement above.

Scale Hoppers are built in the same manner as the ordinary hoppers, except that the hopper is placed on a steel truss which is suspended to, and connected with, a weighing attachment so that any amount of malt or cereal can be weighed off.

[redacted]

Should someone desire to build hoppers himself, employing local mechanics, the following data will afford a basis for calculation:

	Per Bu.	Per Cu. Ft.
Whole malt weighs, average	34—36 lbs.	27—29 lbs.
Crushed malt weighs, average	25—26 lbs.	20—21 lbs.
Barley	48—50 lbs.	38—40 lbs.
Grits	53—54 lbs.	42—43 lbs.
Meal	46—47 lbs.	36—37 lbs.



Meal Scale Hopper.

Malt when crushed increases in volume, three bushels of whole malt on an average giving four bushels of crushed malt, which should be considered in building hoppers.

For calculating contents of square or round bins with hoppers, see "*Mensuration.*"

DUST COLLECTORS.

In order to collect the malt dust liberated during the handling or treatment of malt, dust collectors are used.

As there is always more or less dust where malt is handled, special devices for collecting it are installed. The kind generally in use consists of a central revolving cylinder into which the dust is drawn by suction. Around this cylinder and opening into it are attached a series of radical tapering cloth tubes, or sacks, arranged in straight parallel rows. As the whole device revolves, the dust falls from the cylinder into the sacks, which can be removed for the purpose of emptying or cleaning.

Caution.—Malt and grain dust is highly explosive when brought in contact with a flame.

MALT POLISHERS.

It is not advisable to polish malt, as polishing removes too much of the hull, thereby reducing the amount of the filtering material much needed in the mash tun.

MALT MILLS.

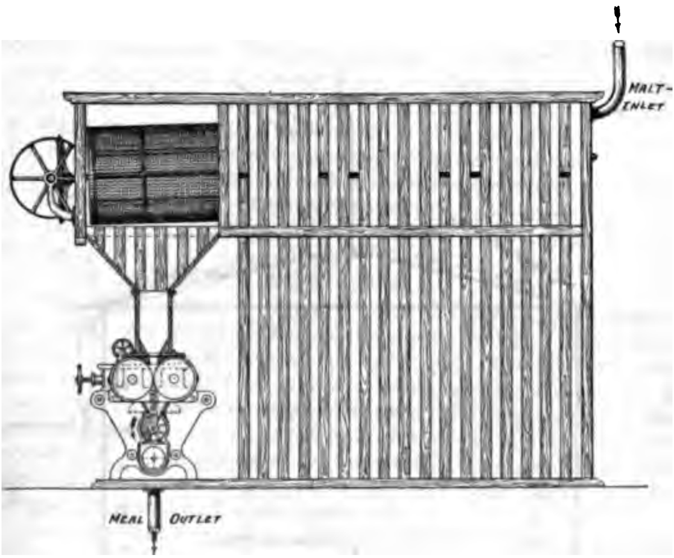
The object of the malt mill is to crush the malt for extraction in the mash tun. The malt should not be crushed too fine, as such treatment will impair the running of the wort. Only smooth rollers should be used for crushing, and the hull should be split open lengthwise and not torn, as would happen if corrugated rollers were used. There should be no whole corns in the crushed malt; even the smallest should be split open.

Most modern malt mills are constructed on the same general principle, and consist of two smooth rollers, one driven by a belt or chain and the other following by friction of the grains between the two. This second roller is adjustable so that the space between the rollers can be regulated to suit the degree of fineness desired in the crushed malt. Before the malt drops between the rollers it runs over or between a series of steel magnets where tacks, nails, or other particles of iron which might damage the surface of the rollers or the mill generally, are removed.

Non-Explosive Malt Mills. As very fine dust from malt or grain explodes readily on ignition, which, in malt mills may occur and supplied with a device for safety from explosions. This con-

by friction of bearings or by a piece of flint or metal passing *between the rollers,* etc., these mills are built of steel and iron

struction, however, does not prevent the possibility of an explosion. The term "non-explosive" applies to their arrangement being such as to render any explosion harmless by confining it to a certain space in the mill, this space being provided with a blow-off spring flap or door which, after the explosion occurs, closes immediately, smothering the flame that may burn inside, and, with a seal below, practically prevents any flame from communicating to the ground malt and bins below. This lower seal consists in some styles of a revolving drum or wheel always



Malt Mill and Screening Reel.

partly filled with crushed malt and acting similarly to a "trap" used for liquids.

Malt mills with wood casing often have a steam extinguishing device, the explosion either causing a steam valve to open or breaking a connection. In no case are these mills secure.

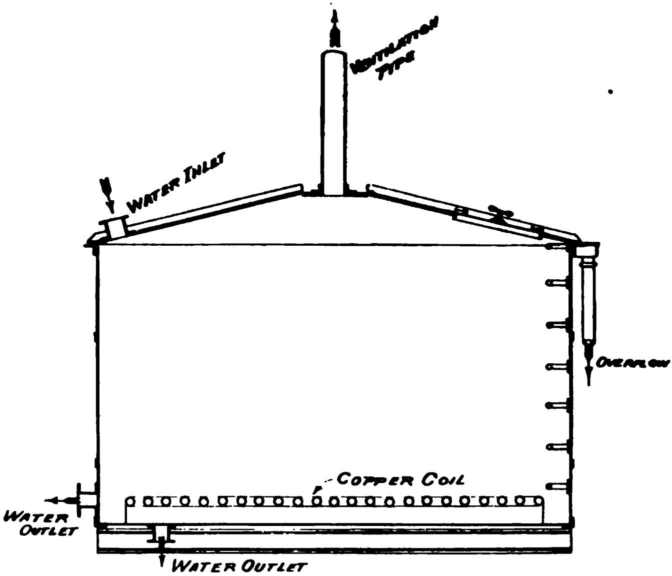
In selecting a reel and mill the brewer should see that it has such a capacity, guaranteed by the manufacturer, that the amount of malt necessary for one brewing will run through in one hour without crowding.

WATER TANKS.

Water tanks in brew-houses are now made mostly of sheet iron or steel, either round or square in shape. They should be supplied with liquid volume gauges or "tell-tales" so that the quantity of water withdrawn can be readily read off, also with a thermometer to register the temperature of the water.

All tanks containing warm or hot water should be well insulated. (See Insulation.)

Hot Water Tanks. They are used to supply hot water for doughing-in, mashing up, final mashing, sparging grains and hops, and cleaning.



Hot Water Tank, sectional view.

The water is heated either by live steam, exhaust steam, or by a steam jacket Where the steam is pure, that is, where it imparts no odor or taste to the water due to impurities in the boiler water or the use of improper boiler compounds, direct or live steam may be used as it is the most rapid and efficient method of heating water. Heating by exhaust steam from the engine

[redacted]

or pumps in a more economical method, but it is uncertain as to regularity of temperature on account of the difference in the amount of steam supplied by the machines at different times. Exhaust steam should preferably never discharge into the water, but enter and leave through a copper coil placed at the bottom of the tank. This is on account of its liability to contain lubricating oil from the cylinders of the machines and giving it off to the water.

For using water of medium temperature a mixing tank is sometimes used where the cold and hot water can be mixed to any desired temperature. This arrangement is, however, almost entirely supplanted by a mixing valve, in which the hot and cold supply pipes are run together, the joint fluid being then run into a larger or delivery pipe into which a thermometer is inserted. By regulating the proportionate flow of the hot and cold water a mixture of any desired intermediate temperature can be delivered.

Cold Water Tanks. These are constructed similarly to hot water tanks except that they are not insulated and have no heating device.

LIQUID GAUGE.

The liquid gauge "swimmer," or "tell-tale," now generally used, consists of a float to the top of which is attached a cord or chain, which passes up and over two pulleys and then down in front of an indicator board, and is held taut by a weight. The tank being filled with water, the float rises and the weight descends, and as water is drawn off for use the float descends and the weight rises. By having the board graduated with lines or marks the rising of the weight past these marks will indicate the quantity of water drawn off.

In graduating this board proceed as follows: Run in a small amount of water, say 5 barrels, accurately measured (enough to raise the float from the bottom), and make a mark on the board where the bottom of the weight touches it. Mark this line "five barrels"—next fill the tank with an accurately measured amount of water, and again make a mark on the board where the weight now touches it, say it was 100 barrels. If the tank is cylindrical or square, the sides are parallel and all that is left to do is to take a rule and divide the board as desired, into 1, 2, 5 or 10 barrel marks. Where the tanks have irregular or tapering sides each division on the scale must be measured and marked separately by adding a corresponding amount of water first accurately measured.

Principal Specifications for Water Tanks. In small plants having 25 to 50 barrel kettles, the water tanks should have a capacity of twice that of the kettle. The ratio of tank to kettle gradually decreases as the kettle becomes larger. For a 400-barrel kettle the tanks should hold about 1.5 times that amount.

Cold water tanks, and hot water tanks heated with live steam, can be made in almost any ratio of diameter to height, as may best suit the building. But in hot water tanks heated with an exhaust steam coil, the diameter or bottom should be made large enough to accommodate a coil of sufficient length to heat the water to the best advantage. This coil is usually made of 2½ inch, 16 gauge, copper tubing for smaller tanks, and 3 inch for larger ones. The total heating surface of the coil should be not less than 0.5 square foot per barrel of water for small tanks, or 0.33 square foot per barrel for large tanks.

CEREAL COOKERS.

Cookers are used for the purpose of gelatinizing the starch contained in raw or unmalted cereals. The starch is thus prepared for more complete and rapid inversion in the mash tub. Cookers should be well insulated. See "Insulation."

Rice Tub. The most widely used form of cooker is the rice tub. It consists of a cylindrical vessel, generally made of sheet iron or steel, though sometimes of wood, and contains a stirring device. This device consists of a central revolving vertical shaft driven by a cog-wheel from above and having attached to, and radiating from it a series of stirrer arms placed in a spiral position above one another at different heights. These arms revolve at a speed of from 10 to 30 revolutions per minute, according to the size of the tub, and stir the mash so as to keep it at a uniform temperature and consistency.

The rice tub is heated either by live steam, a steam coil, or a steam jacket.

Where the steam is pure, that is, imparting no taste or odor, it should be used direct, as *live steam* gives the greatest and most rapid work. Here the steam is conducted by a two-inch circular main pipe, placed around the tub and branching off into the tub through six openings provided with check valves. These check valves prevent the mash from entering the pipe when the steam *is turned off.*

If a steam coil is used it is generally a two or three inch circular

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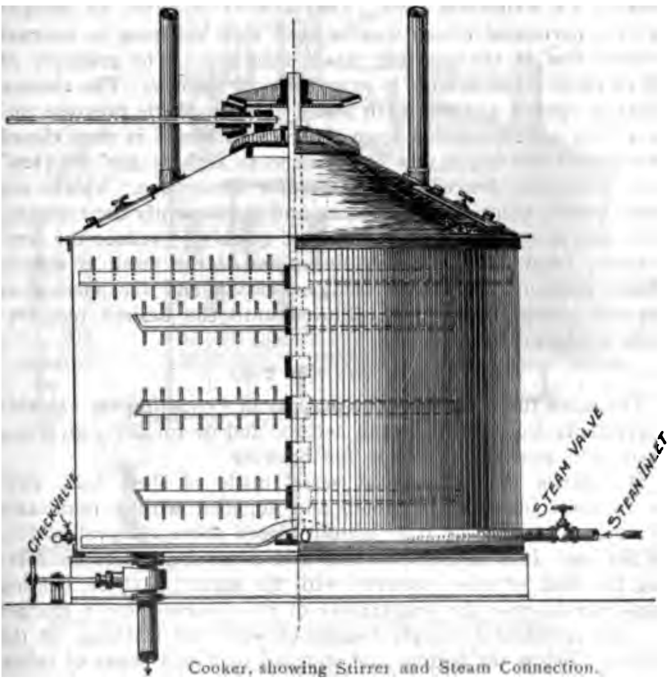
copper pipe placed close to the inner wall and at a position about four inches above the bottom. Sometimes a one or one and a half inch coil of several turns placed above one another is provided.

The *steam jacket* is placed under the bottom and extending about two feet up the sides of the tubs.

In the last two arrangements there is danger of scorching, if the mash is too thick.



Cooker, showing Stirrer and Steam Connection.

Size and Appliances. Rice tubs are made smaller in their capacity than the kettle, being usually 50 to 60 per cent as large according to the size of the plant. The ratio of diameter to height is variable, according to the dimensions of the room where it is to be placed. An accurate thermometer should be attached to every rice tub so that the temperature of the mash inside the tub can be read from the outside. This is a great convenience.

since it obviates the troublesome and sometimes confusing method of taking the temperature with a thermometer at the top of the tub.

Pressure Cookers. It has been found that by boiling cereals at a higher temperature than can be obtained in an open cooker (viz., 80° R. or 212° F.), the starch contained in them can be better and more perfectly gelatinized. On that account pressure cookers are frequently used. They consist of either an upright or of a horizontal closed iron or steel shell differing in internal construction of stirrers, and steam inlet jets. The principle of all of these constructions is practically as follows: The closure cover is opened and the mash boiled at atmospheric pressure until all the air is expelled from the cooker, which is then closed and heated under pressure by steam to as high as 302° F. (120° R.), or to any desired temperature for some time. Valves are then opened, reducing the pressure and consequently the temperature, and should it be desired further quickly to reduce the temperature below that of the boiling point of the mash at atmospheric pressure the cooker is again closed and the suction or vacuum pump started and operated until the desired temperature is obtained.

MASH TUN (OR TUB).

The mash tun is used for the purpose of extracting the valuable ingredients from the malt and cereals, and of further converting them into products desirable for brewing.

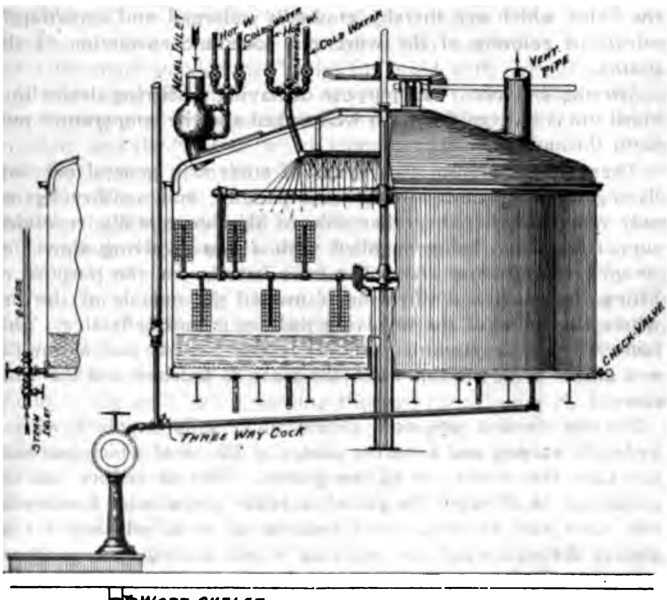
It consists of a cylindrical vessel made of sheet iron, steel or in some instances of wood, and supplied with a removable perforated strainer or false bottom placed above the real bottom of the tun. It is further provided with a stirring device for mixing the malt or other material with the water; a steam heating appliance to raise the temperature of the contents, and a sparger or over-sprinkler to supply a spray of water for washing out the grains. Below the bottom and attached to it is a series of tubes, each having a stop cock at the outer end, and all delivering into a cylindrical copper vessel called the *Grant,* from which it can either be pumped back into the mash tun or run into the kettle.

Double Deck Mash Tuns. These mash tuns have a hood attachment with doors in the sides instead of at the top. They are generally provided with high arm stirring devices.

Wooden Mash Tuns. These are mostly ordinary wooden tubs of variable height and diameter, without stirring devices, and

generally have an ordinary piece of perforated sheet copper serving as a false bottom or strainer.

Separate Mash Tun. Here the mash tun is constructed similarly to the form first above described, excepting that it contains no false bottom, the latter being placed in a separate tun, called the clarifying tun (Läuterbottich), into which the wort is run after the mash is finished, and there filtered or clarified.



Mash Tun, with Foremasher, Liquid Gauge, Attemperating Device and Three-way Cock.

PARTS OF THE MASH TUN.

False Bottom or Strainer. This consists of a sheet copper disc, of the same size as the tun bottom, and should be placed no further than one inch above the latter (see Brewing Operations) and perforated with conical or tapering holes arranged three-eighths inch apart. These holes or perforations have their smaller diameter at the upper side of the false bottom, being usually one-eighth or three thirty-seconds inch

in diameter, and their larger one below. This form prevents clogging or stopping up, as any particles lodging in the upper and smaller opening are easily pushed or sucked through. The false bottom, in order to allow its being removed and replaced by one man, is cut into sections with tight fittings edges.

False bottoms are sometimes made of galvanized iron, but this is not to be recommended, as they rust easily, especially around the holes which are thereby gradually enlarged and accordingly affect the running of the wort and economic extraction of the grains.

Stirring Devices. The purpose of having a stirring device in a mash tun is to keep the mash well mixed and the temperature uniform throughout.

There are at present two forms of stirrers in general use, one having two sets of revolving claw paddles, and another having only one such set, the other side of the horizontally revolving supporting beam being supplied with a non-revolving shovel or scraper, placed close above the false bottom for the purpose of lifting the mash and throwing it toward the outside of the tun where the action of the revolving paddles is more effective. This non-revolving or stationary shovel is also used to throw out the wet grains from the tun when the mash is finished and the wort run off.

Stirring devices are now almost universally supplied with a hydraulic raising and lowering pump, by means of which one man can raise the stirrer out of the grains. This procedure has the advantage of allowing the grains to settle into a more homogeneous mass and avoiding the formation of so-called channels or gutters through which the sparging water, finding less resistance than through the more solidly packed grains, will naturally take its course. If this is allowed to occur the result is poor extraction of the grains and it becomes necessary frequently to remix or remash the grains (Umhacken or aufhacken) by the stirrers.

Spargers (*Überschwaenzer*). Two kinds of sparging devices are now in use, the rotary and the ring spargers, of which the latter is most generally employed.

The *rotary sparger* consists of two or more arms of perforated copper tubes attached at one end to a revolving head, the perforations being in such places in the tubes that when water is allowed to run through them it issues in jets and causes the sparger to revolve and distribute the water over the grains.

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The *ring sparger* consists of a stationary circularly bent copper tube placed near the top of the mash tun, having holes drilled through its lower side slanting in such directions that the water issuing through them is evenly distributed over the surface of the grains.

Of more antiquated forms of spargers, but such as are still occasionally found in use in older plants, may be mentioned: The "spritzkopf" or spraying head, which consists of a perforated nozzle attached to a hose through which the water is sprayed over the mash goods; the "sprinkler" used with open mash tuns, and consisting of a tin or iron can of three to five gallons' capacity, having a spraying nozzle attached, to which is given a rotary motion; and the "board" which consists of a wooden plank, about two feet square, near the outside of which numerous holes are arranged. The nozzle of a hose is placed against the center of the board which is suspended over the mash and the water running off through the holes produces the desired spray.

Pony Mashers or Foremashers. These devices are used for the purpose of moistening the crushed malt before it enters the mash tun so as to prevent its caking or sticking together, or of any fine malt dust being lost by rising out of the mash tun. The different forms of construction all have the similar purpose of dividing the malt, while passing through them into a thin stream or layer, and while in this condition, bringing it in contact with a fine spray of water. This is done either by running the malt over a cone-shaped obstruction, or dropping it upon a revolving paddle wheel. In both processes the water enters from the side of the foremasher in finely divided jets.

Grant and Wort Pipes. The grant consists of an horizontally placed cylindrical copper vessel with closed ends and supplied with doors or lids in its upper part. The purpose of the grant is to furnish a temporary receptable for the wort while it is being examined, and from it the wort is either pumped back into the mash tub, or run into the kettle. The grant sometimes consists of an open vessel or wooden tub. But this form is no longer supplied with new outfits.

Should it be desired to withdraw a "lautermash" from the main mash, the grant, if large enough, can also be used as a receptacle for storing this lautermash until it is returned to the mash tub, thereby doing away with an extra vessel for that purpose.

The wort pipes consist of a series or batteries of copper tubes, four to ten in number, connecting the mash tub with the grant. These tubes start from different points in the bottom of the tub and run together into the grant, at which end each is supplied with a stop cock.

Underlet or "Pfaff." At some place between their ends these tubes are cross-connected to a header (underlet or "Pfaff") so as to enable water to be run under the false bottom and upward through the mash.

The upright tubes of the underlet, connecting the header with the wort pipes, should each be supplied with a separate stop cock. This makes it possible, by closing the cocks of the other pipes, to force water from the tanks above through any one pipe at full pressure, enabling quick and thorough flushing of such pipe and affording a means of dislodging with greater ease any obstructions that may have become fastened therein.

The arrangement found to give the best results is to employ eight to ten of these tubes and have each connect with one opening in the mash tub bottom only. It has been found that if one tube is connected with more than one opening the wort will run unevenly and hence the grains will be imperfectly extracted. In some cases the wort pipes are connected with a copper pipe placed around the outside of the mash tub and delivering directly into the kettle, thus dispensing with the grant.

Whatever the arrangement may be the slant or pitch of the wort pipes should be no more than necessary to allow the wort to run through and out of them, as otherwise the wort in the pipe may create a suction and cause either the strainer holes to become stopped up or the wort to run off turbid.

Mash Tub Thermometers. These usually consist either of a thermometer placed flat against the outside of the tub, having its mercury bulb bent at right angles and extending through the wall of the tub into the mash, or of the long stem style of thermometer, consisting of a thermometer of such length that the scale extends above the top of the mash tub, while the mercury bulb reaches down into the mash. In either style the glass parts are protected by slotted or perforated brass housings.

Recording Thermometers consist of a tube running through the mash and filled with ether, the other end of the tube being *connected* with a gauge. As the mash is heated the ether in

the tube expands and presses upon the gauge, the latter being supplied with an indicator dial.

Safety Mash-Tun Gauge.—Every separate filtering tub or combined mash and filtering tub should be supplied with a liquid gauge. This consists of a glass tube, from one to one and one-half inches in diameter, attached to the tub with its lower end inserted into an angle valve with a tube having an opening of equal size as the glass tube, and running into the tub under the false bottom. The upper end of the tube is open. A steam connection is made between the angle valve and mash tub so that steam can be blown through for cleaning.

The principal advantage derived from the use of this gauge lies in the fact that the flow of the wort can be perfectly regulated, and any suction under the false bottom created by too sudden opening of the cocks while tapping the wort is indicated by the dropping of the wort in the gauge to a lower level than in the mash-tun, or its entire disappearance. In this case the suction would be apt to clog the holes in the false bottom, and result in subsequent slower running of the wort. It therefore gives a perfect indication as to the proper or maximum opening of the taps allowable for proper running of the wort.

Another benefit derived from the use of this gauge is that it indicates the quantity of mash or water in the tub.

This gauge was introduced for above purposes by M. Henius about ten years ago.

HEATING THE MASH.

The mash is heated by means of direct or live steam, a steam coil, a steam jacket, or hot water.

Of all these methods, that of employing *live steam,* provided it is pure and does not impart any taste or odor to the mash, has been found to give the best results, and is now in general use. By this method a circular one to two and one-half inch pipe is placed around the bottom of the mash tub on its outside, the pipe having six or more branches, with check valves, leading into the mash directly above the false bottom. These branches distribute the inflowing steam in such proportions that the stirring device can readily keep the mash at a uniform temperature; to divide the steam either too much or not enough leads to detrimental results. In the case of too fine distribution, that is, if a circular steam pipe with too small perforation is laid inside the *edge of the bottom* of the tub the mash would be overheated

at that part and the stirrers and shovels would have to work the hot mash to the center in order to mix the whole mash. In the case of insufficient distribution, on the other hand, that is, if one large steam inlet only were used, the steam would overheat a part of the mash in a straight streak, across the mash, and the stirrers would take considerable time in equalizing the temperature of the whole mash.

In either case the indication of the thermometer at the time the steam was shut off would be misleading, as that part of the mash near the steam inlets would be much hotter than the bulk of the mash, the disadvantage of which needs no explanation.

The *steam coil* and *steam jacket* cause a similar uneven heating of the mash, and have the additional disadvantage of consuming more steam than would be necessary if live steam were employed.

To heat the mash with hot water, such water is first heated in a separate tank, and run into the mash through the underlet and false bottom. The objection to this method is that a wide range of temperatures is not allowable, and high initial temperatures must be used or the mash becomes too thin. Furthermore, the amount of water that can be used for sparging the grain becomes limited too much, which results in less perfect extraction of the grains and loss of extract.

GRAINS TANK.

A grains tank generally consists of a round or square covered iron or steel tank, having a conical bottom. These tanks are usually placed outside of the brew-house in such a position that the grains readily slide or fall into them by gravity, when thrown out of the mash tub. They are sometimes placed inside the building and have discharge tubes extending to the outside.

The grains tank is supplied with a delivery valve at the bottom; also a drain pipe to carry off any water that may settle if the grains are kept in the tank for some time.

FIRST WORT PUMP.

A pump for returning the first turbid wort to the mash tub or for pumping sparging water, where such work is necessary, should be conveniently placed. This pump may also be made to answer for the purpose of pumping wort from the kettle to the surface cooler.

This pump should be specially constructed for the purpose, and have the valve seats made larger than in ordinary pumps, so as to prevent clogging of the valves. It quite frequently happens,

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while pumping back first wort, that the moment the grant is empty, or before all the liquid has been discharged from the pump cylinders, the pump is stopped and some of this heavy wort is allowed to remain in the pump, giving the solid particles an opportunity to settle and stick in the valves. It is therefore necessary to pump sufficient water through the pump after each brew to displace any remaining wort.

Duplex or double cylinder pumps are preferable, as they furnish a more even discharge, and can be better depended on than the single cylinder pumps.

THE KETTLE.

The kettle is a vessel in which the wort is boiled for the purpose of precipitating its albuminoids, of extracting the bitter principle and oil from the hops, and of concentrating and aerating the wort.

Kettles are built in different shapes, but the pear-shaped closed kettle is now in almost universal use. Other forms are square or cauldron-shaped, the latter generally being open kettles, supplied with a hood for carrying off the vapors.

The *pear-shaped modern kettle* is heated by means of a steam jacket. This consists of a jacket or double bottom placed around the bottom of the kettle, the space between being crescent-shaped and forming the steam chamber where steam is injected under pressure and heats the wort in the kettle above.

In order to allow the use of steam directly from the boiler where the pressure ranges from 60 to 90 pounds, which is much too high to be used for heating the kettle, a pressure-reducing valve is placed in the steam run which allows the steam pressure upon the kettle to be regulated at will.

Some kettles have copper *steam coils* placed inside near the bottom and directly in contact with the wort, while others again are heated by direct fire from underneath. These *fire kettles* are generally open kettles, built over a brick furnace, and fired by means of coal, coke or wood, the heat being regulated by a series of drafts and dampers placed in the walls of the firebox. Fire kettles are gradually going out of use, since the steam kettle has been found much more economical and reliable.

Fire pans are constructed similarly to fire kettles, the difference being in that they are more pan-shaped, so that a greater heating surface may be exposed to the fire.

Steam Traps. In order to obtain a back pressure and allow

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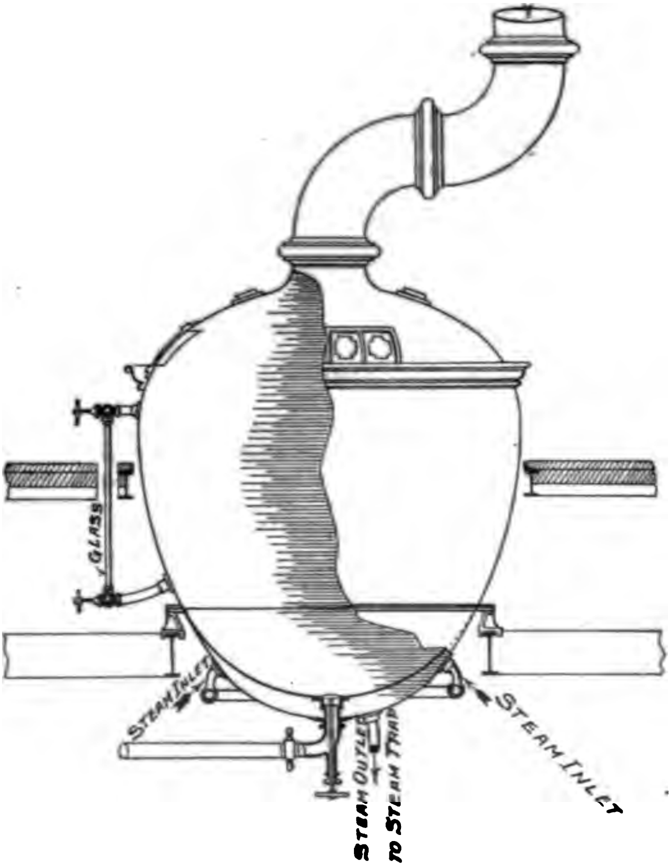
the water of condensation to escape, a steam trap is placed at the steam outlet of the kettle.

Steam traps are mainly of two kinds, diaphragm and float traps.



Brew-Kettle, showing Liquid Gauge, Steam Jacket and Steam Connections.

Diaphragm steam traps consist of a flattened sphere divided *into two chambers* by a copper disk. This disk is fastened on *top, the lower* part being loose so that the steam pressure and

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condensation causes the disk to vibrate slightly, allowing the condensed water to pass to the other side of the disc where it is discharged through a pipe.

The *float trap* consists of a pot-shaped vessel containing a thin copper cup, acting as a float on the condensed water, and closing a discharge valve at the top. When the condensed water in the trap reaches a certain height it flows into the cup, thereby sinking it, by which the discharge is opened and the water forced out of the trap by the steam pressure. When the cup is empty it again rises and closes the discharge valve, this operation being automatic.

HOP EXTRACTION APPARATUS.

This is used for the extraction of the hops and preventing volatization of the oil of hops. It consists of a closed cylindrical steel tank, having a conical bottom and fitted with a stirring device. First wort is pumped into the tank, the hops added, and this decoction brought to a boil by means of live steam. The doors are then closed and the hops further boiled under three to four pounds' steam pressure. The hopped wort thus obtained is then collected and subsequently added to the wort, either in the kettle at the time it is run out or in the settling tank. The hops left in the extractor in the meantime are transferred into the kettle and boiled with the main wort before it is run out.

HOP AROMA OR HOP OIL CONDENSER.

This consists of a copper vessel affixed to the ventilator of the kettle. It contains a series of small tubes through which cold water circulates. A damper, to prevent vapors from escaping through the ventilator, is placed just above the branch pipe for the condenser. When the hops are added, this damper is closed and the cold water supply turned on, the volatilized hop oil is condensed around the tubes, and flows into a collecting receptacle placed at the bottom of the condenser. After the oil is distilled over, the damper is again opened and the vapors allowed to escape through the ventilator in the usual manner. This recovered hop oil is then added to the wort in the fermenting tub.

HOP SEPARATING MACHINE.

This machine has the object of separating the lupulin of the hops from the leaves and stems.

The hop cones are torn apart and by means of screens or sieves *having an oscillating* motion, the coarse leaves are separated from

the lupulin and more finely divided leaves. The coarse leaves are added in the kettle as the first lot of hops, and the lupulin, etc., is either used in place of the second addition of hops in the kettle, or else added in the hop-jack.

WORT CONCENTRATOR.

This appliance consists of a closed vessel having steam coils for heating purposes and being connected to a vacuum pump so as to allow its contents to evaporate at a lower temperature.

The last spargings are run through the concentrator, where they are thus boiled under reduced pressure and run into the kettle. This device has, at present, been installed only in large plants where several brews are being made continuously. By its use from 15 to 20 per cent more sparging water can be employed, resulting in an increase in the yield of the materials.

HOP-JACK.

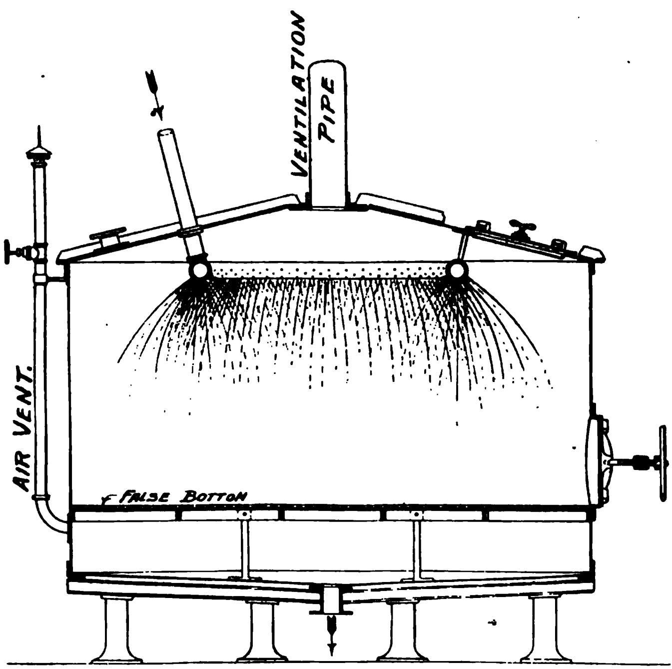
The hop-jack has the purpose of straining out or intercepting the hops contained in the wort after leaving the kettle.

The hop-jack is made of steel, either round or square in shape, and supplied with a false bottom or strainer similar to that contained in the mash tub. The difference, however, is that here the false bottom is placed from 4 to 18 inches above the real bottom, instead of only three-fourths to one inch as in the mash tub. The object of this higher space below the strainer is to furnish a larger bulk of filtered wort for the pump to draw from, thereby giving an uninterrupted flow to the cooler and at the same time preventing too much suction under the false bottom, which might cause the holes in the latter to clog by particles being drawn into them.

In order to avoid the wort standing in contact with the hops too long, which will happen if the pump or cooler is of insufficient capacity, and cause the hops to impart a rank bitter taste to the wort, it is advisable to raise the false bottom to such a height in the hop-jack that the space between the bottoms will hold at least one-half of the filtered brew. This raising of the false bottom is practically a necessity in the new arrangement now being frequently installed in new breweries, where the hop-jack is placed above the cooler and the wort, with the hops, pumped up into it with a rotary pump, the hop-jack thus also taking the place of the beer tank or surface cooler.

The difference between the regular and this new arrangement

as to the length of time the wort remains in contact with the hops is, that in the former, with the hop-jack placed below the kettle, the wort can be pumped out of the hop-jack and away from the hops as fast as it will strain through the false bottom, whereas in the latter arrangement where the hop-jack is above the cooler, the hops will remain in contact with at least part of the wort



Hop Jack, sectional view.

during most of the time required for cooling, and the lower the false bottom is placed in the hop-jack the greater is the amount of wort that thus remains in contact with the hops.

The *sparger* for washing out the hops is constructed in the same manner as the sparger contained in the mash tub, except that when placed in square hop-jacks, it is one straight perforated pipe.

Hop Sparging Apparatus.—Since the surface of the strainer in the hop-jack is proportionately large and causes the hops to be spread out into a very thin layer and not admit of their being sparged properly, it is advisable to sparge the hops in a separate vessel. This vessel then takes the place of the hop press and can be constructed in a similar manner. The basket of the old hop press should be displaced by a cylinder of sheet-iron, and a sparger, like that in the mash tun, be affixed for spraying boiling water over these hops.

Should this hop sparging apparatus be newly constructed it should be so proportioned that the hops from the brew, when thrown into it, would lie about three feet deep. In this construction it may, however, be inconvenient to throw out the hops, but this defect could be readily remedied by having the cylinder containing the hops, detachable or merely resting upon the strainer or strainer-housing so that in removing the hops it would be necessary only to lift the cylinder, when the hops would fall out similarly to lifting a barrel whose bottom had become loosened or broken.

HOP PRESS.

This consists of an upright cylinder made of perforated galvanized iron in which is inserted a tight-fitting plate, or plunger, movable up and down by means of a screw.

The hops are thrown out of the hop-jack into the press, where any remaining wort is squeezed out and subsequently added to the bulk of the wort.

This pressing of the hops is not advisable. The amount of wort recovered is small and contains so large an amount of the coarse and undesirable principles of the hops as to more than outweigh the advantage of recovering this small amount of wort. The hops should be sparged with hot water. (See "Hop Sparging Apparatus.")

WORT PUMPS.

The pump used for elevating the wort from the hop-jack to the cooler must differ from the mash tub pump in having a much greater delivery capacity, and also in being of the high pressure type on account of the height, often considerable, to which the wort must be pumped.

For this purpose, where the delivery is of moderate height,

centrifugal pumps have found extensive service, since large volumes of wort can be quickly raised by them.

Rotary pumps are also used, but this style of pump gives its greatest efficiency in the arrangement where the hop-jack is placed above the cooler, and where it is necessary to pump the wort containing the hops from the kettle up to the hop-jack, situated at a higher level.

SURFACE COOLER.

This consists of a shallow iron or steel pan, of a length and width very large in proportion to its depth. This form of cooler allows the wort to stand so as to present a large surface exposed to the air, causing rapid cooling and thorough aeration of the wort.

The surface cooler, however, also has the disadvantage that it presents a large surface for impurities to settle upon and infect the wort, for which reason this form of cooler is gradually being abandoned.

WORT OR BEER TANKS.

This tank frequently takes the place of the surface cooler as a receptacle for the wort after leaving the hop-jack and before being run over the pipe cooler.

It is generally made of iron or steel, either round or square in shape.

WORT AERATORS.

These devices are used for the purpose of bringing a large volume of wort in contact with the air in as short a time as possible.

This is accomplished either by forcing the air in finely divided jets or sprays through the wort, or by spraying the wort, in the reverse manner, through the air.

The latter form of aerators consists of a nozzle placed on the end of the wort delivery pipe. This nozzle is either provided with a propeller-shaped wheel, so that when the wort issues it strikes against this propeller, forcing it to revolve and thereby throwing the wort in the form of spray, or else has a metal cone or other shaped plug inserted in the opening, whereby the outflowing solid stream of wort is broken into a spray or rain.

Sometimes these devices are provided with a fan to blow air against the spray and thus intensify the aeration.

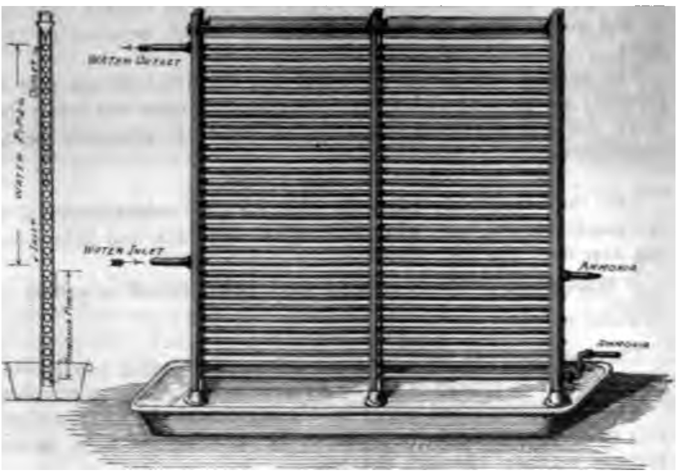
PIPE COOLERS.

The most important of this type is the *Baudelot cooler*. It is used for the purpose of cooling the wort, after being partially

cooled in the surface cooler or beer tank, to the temperature desired in the cellar.

The cooler consists of a series of pipes arranged in vertical tiers, over the outside of which pipes the wort is allowed to flow, while through their insides a cooling medium is circulated.

The wort first discharges into a V-shaped trough placed at the top of the cooler, where it is distributed over the cooler pipes by running out through narrow slits or perforations. The wort then first passes over a series of copper tubes containing cold water, where it is further cooled and then descends either over a second



Baudelot Cooler.

series of copper tubes containing cooled brine, or over a series of iron tubes containing liquid expanding ammonia. In either case the wort is cooled to the desired cellar temperature.

Other forms of cooler are still in use, but they are very slow of action. Such is the *ice-water* or *brine cooler,* consisting of a series of pipes having the inlet at the bottom. Ice-water or brine is circulated from a tank above (or water from a well), and the warm discharge at top is returned to the tank and again cooled and circulated.

All forms of pipe coolers have a collecting pan placed underneath to collect the wort, which runs from there into the starting tubs.

[redacted]

As the wort in passing over open coolers is exposed to infection by germs floating in the air, the cooling process should be as short as possible.

To avoid the danger of infection two kinds of coolers have been placed in use. The first consists of a cooler constructed as described, and surrounded or shut off from the air by means of air-tight glass partitions, the space around the pipe cooler and inside the glass partition being filled with filtered or sterilized air. which is constantly renewed.

The second form embraces a different construction of the cooler itself, which consists of a series of tubes through which the wort flows, and another similar series of larger tubes enveloping the smaller ones, thus forming an annular sleeve through which the cooling media are passed. In this construction the wort does not come in contact with any air, except such filtered or sterilized air as may be forced into it intentionally for the purpose of aeration.

Copper tubes for the cold water and iron tubes for the ammonia circulation are used in the construction of this cooler also.

SIZES AND CAPACITIES OF PIPE COOLERS.

Following are the standard sizes and capacities of coolers made by a leading manufacturer:

No	0 – 7½	ft.	long	21	Tubes	5	ft.	high	cools	9	bbls.	per hour.
"	1 – 8	"	"	23	"	5½	"	"	"	12	"	"
"	2 – 8½	"	"	25	"	5¾	"	"	"	15	"	"
"	3 – 9½	"	"	27	"	6	"	"	"	20	"	"
"	4 – 10½	"	"	27	"	6	"	"	"	25	"	"
"	5 – 12½	"	"	27	"	6	"	"	"	35	"	"
"	5 – 12½	"	"	34	"	7½	"	"	"	45	"	"
"	6 – 15	"	"	27	"	7½	"	"	"	50	"	"
"	6 – 15	"	"	31	"	9	"	"	"	60	"	"
"	7 – 17	"	"	27	"	7½	"	"	"	60	"	"
"	7 – 17	"	"	34	"	9	"	"	"	75	"	"
"	8 – 21	"	"	34	"	9	"	"	"	95	"	"
"	8 – 21	"	"	50	"	13	"	"	"	120	"	"

No. 0 to 5 incl. have tubes 1¾ in diam. No. 6 to 8 incl. have tubes 2⅜ in. diam.

These coolers are made to any length up to 30 feet and any number of tubes in height.

All coolers with 34 tubes or more are made for two kinds of water, the upper part for hydrant water and lower part for ice water. Where brine circulation is in use connections are made so as to circulate brine through this lower part. Where ice machines are installed the lower part is made of polished steel tubes *with the necessary* fittings for connection to the machine.

SIMPLIFIED BREW-HOUSE PLANT.

In order to simplify the general equipment, and, at the same time, the cost of installation, the following arrangement has been proposed by M. Henius in 1892.

The principal implements in this equipment consist of a cooker and an ordinary mash tub, besides the usual malt mill, hot and cold water tanks, and a pump. The cooker is used for boiling the wort, and the mash tub for straining the hops, thus doing away with a kettle and hop-jack.

The cooker may, at a later stage, be used for cooling and aerating the wort and a surface cooler thus made superfluous. The cooker is located above the mash tub and contains a hollow stirrer and a steam jacket, both of which can be filled with steam or cold or hot water. By means of pipes at the bottom, running through the jacket and opening into the apparatus, air, hot or cold water, or steam can be admitted.

The lower implement is a common mash tub, with this difference, that it is equipped with a closing device permitting its contents to be boiled by steam under pressure.

The pump can be used for moving the wort during the different pumping operations necessary, or for drawing a decoction or "Lauter" mash.

The operation is as follows: The corn mash is put into the upper cooker, the stirrer started, and the mash made as ordinarily, with or without pressure. In the meantime the malt is doughed-in in the mash tub below, and the corn mash is then run down into it. The clear wort is then pumped up into the upper cooker and boiled, and when finished is run down into the mash tub, which then is used as a hop-jack. The wort is then again pumped into the upper vessel, where it is cooled by passing cold water through the stirrers, and aerated with filtered air. The wort then passes through a closed cooler into the cellars.

The advantages offered by this apparatus are the following:

1. Very simple management;
2. A great saving in first cost;
3. It is easy to watch the whole process;
4. A saving of labor;
5. A brew-house of two stories could contain all the apparatus *and machinery* needed for preparing the wort.

CELLAR OUTFIT.

STARTING OR SETTLING TUBS.

These tubs are used as receptacles in which to start fermentation. In them the yeast is added to the wort (pitching), and the albumen and resinous substances, precipitated while the wort is cooled, are allowed to rise to the surface of the fermenting wort.

Starting tubs are built of wood, generally cedar, or of steel, and in shape are round, oval, or square with rounded corners.

They are nearly always built of a size capable of receiving a whole brew, and are constructed with tapering sides in order to allow the hoops to be driven on or tightened. This tapering construction is in use in nearly all the cooperage throughout the brewery, the curved sides of the chip cask, etc., answering the same purpose. If the side of the tubs are parallel, the hoops must be supplied with a screw tightening device, but this construction of tubs is not generally in use.

AERATION AND PITCHING OF WORT.

(Aufziehen.)

One style of device for aerating and pitching the green wort consists of an air filter containing cotton, below which a bulb carries an injector. The filtered air is forced through the injector and carries along with it a large quantity of wort, both then passing through a perforated cap, thus mixing as well as aerating the wort.

Other methods of mixing and pitching the wort are either by means of a pole, to which a perforated pail is attached, or by means of an oar-shaped paddle. In both cases the wort is thoroughly agitated with these implements by hand.

Bucket Aerators. This consists of a tub or vat into which the yeast and an equal quantity of wort are brought. A vertically placed wheel, to which a number of buckets are attached, is then revolved inside of this tub. This causes the wort and yeast to be carried upward in the buckets and emptied or thrown back into the tub at each revolution, thus mixing and aerating the mass thoroughly, providing a supply of pure air is carried to the mixer during its operation.

The spiral mixing machine consists of a tub in which the wort and yeast are agitated by the action of an Archimedean screw.

Yeast and wort are also mixed in copper or tinned buckets, by *being poured* from one into the other until thoroughly mixed

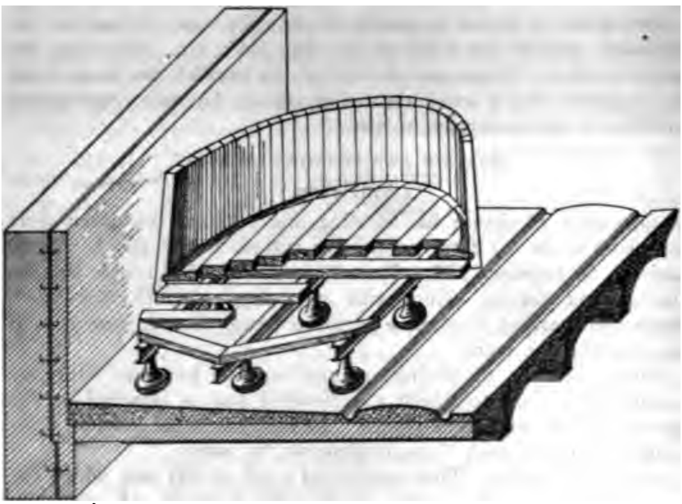
and aerated. This simple method is very popular and much used at the present time.

YEAST TUBS.

These generally consist of oval oaken tubs, varnished on the inside, and from 12 to 18 inches in depth. The best material for the construction of yeast tubs, however, is copper, as it requires no varnishing and is more easily kept clean.

ATTEMPERATORS FOR COOLING YEAST.

Brine attemperators generally consist of a one-inch iron pipe coil suspended in the yeast tub over the yeast through which



Tub Support.

cooled brine is circulated. This arrangement has the purpose of preventing the yeast from freezing to the coil. If care is taken, however, in regulating the amount of brine circulated through the coil, the coil can be placed in the yeast directly, which is a preferable method, since less brine is used to keep the yeast cool.

Sweet Water Attemperators. These implements are constructed similarly to the brine attemperators, with the exception that the coil is made of copper pipe. Ice water is circulated through them and consequently they can be submerged into the yeast if desired.

[redacted]

Bucket Attemperators. These are copper or tin buckets into which ice is placed, the buckets being then placed into the yeast.

KRAEUSEN METER.

This is a device for measuring the amount of Kräusen added to the beer, or for determining the capacity of utensils or vats used in the brewery.

The essential feature of the most commonly used style consists of an internal revolving wheel, similar to a water-wheel. The Kräusen, as it passes through the meter, pushes against the arms or paddles of this wheel and revolves it until reaching the air outlet. The compartment surrounding the wheel being of known volume, by counting the number of revolutions of this wheel the amount of Kräusen that has passed through can thus be estimated. This is done automatically by connecting the shaft of the wheel to a dial indicator.

FERMENTING ROOM.

FERMENTING TUBS.

Fermenting tubs are used as receptacles for the wort during its principal fermentation. They are usually made of wood, generally cedar, and of a capacity to hold 50 to 100 barrels of wort. If too large, that is, too high, fermentation is retarded and the yeast weakened. From 5 to 6 feet of liquid is the average depth employed.

ATTEMPERATORS.

Attemperators for fermenting tubs are devices placed in the tubs for the purpose of cooling the wort during fermentation, or in other words, to carry off the heat generated by fermentation. The usual form is an iron or copper pipe coil through which the cooling medium, cooled brine or sweet water, is circulated.

The *brine circulation coils* are usually made of one to one and one-half inch pipe, bent in a circular shape and supplied with swivel joints so that they can be pushed upward and out of the tub. They are usually suspended so as to be immersed about two feet below the surface of the wort.

Sweet water attemperators usually are made of copper, two-inch tube coils, either round in shape or straight with return bends. In either case they present a larger surface to the wort than the brine coils.

The double cylinder attemperator is sometimes used. It con-

sists of two copper cylinders, of which one, somewhat smaller, is placed inside the other so that there is formed a cylinder having double walls, about one-half inch apart. A wire or rod is soldered inside this annular space in a spiral direction from the bottom to the top so that the cooling medium, in passing through, is evenly distributed throughout the attemperator. This attemperator is suspended in the wort, and is provided with a raising and lowering pulley.

Another similar, but simpler, form of attemperator consists of a double cylinder having walls about three-quarter inch apart and connected together at top and bottom so as to form a jacket. Brine is circulated between these walls from bottom to top. This form of attemperator can be used only for small tubs.

Swimmers consist of a half-globe-shaped vessel, about three feet in diameter, used for cooling the wort. They are filled with ice and floated upon the surface of the wort.

COVER REMOVER.

This implement consists of a shallow perforated copper ladle or spoon, about one foot in diameter, attached to a wooden handle, and is used for the purpose of removing undesired parts of the foam cover of the fermenting wort.

YEAST REMOVER.

This is a long pole, to one end of which is attached a thin edged board, about two feet long. With this the yeast is scraped along the bottom of the tub toward an opening through which the yeast falls into receptacle underneath.

YEAST SIEVE.

Yeast sieves consist of a wooden or metal frame, supporting a brass wire or horsehair sieve cloth, having about 40 meshes to the inch.

YEAST WATERING APPARATUS.

A wooden tub about three feet in height, having bored in the side a series of vertical holes, each placed at a different height. Each hole is supplied with a removable plug so that the water can be gradually drawn off as soon as the yeast has settled, thus preventing agitation which might cause the yeast to rise. This happens to some extent when the vat is tilted and the water ired off over the top edge.

STOCK CELLAR.

STOCK OR STORAGE VATS.

Stock or storage vats are used as receptacles for holding the beer while it is undergoing the secondary or after-fermentation or ripening process, and for general storage of the beer.

They are generally of upright form, closed at the top and constructed of cedar wood, of a size to hold from 50 barrels upward to an almost unlimited capacity.

Another style of stock vat consists of steel cylindrical vessels coated on the inside with glass enamel.

Tub and Vat Supports. In later constructions of breweries the supports for vats and tubs consist of two steel rails or I-beams laid along the entire length of the cellar and supported by cast iron legs, the vats resting upon the rails or beams. In many plants wooden beams are used instead of iron ones.

Manhole Doors. The ordinary form consists of a door placed outside of the vat, at a position near its bottom, and closed by means of two lugs which fit into extensions at the top and bottom of the manhole ring. The door is then fastened by means of a screw bolt.

Another style of manhole door consists of an iron door opening inward, the door being secured with lugs to the upper and lower outside supporting ring of the door, and fastened by means of a screw bolt. This manhole is usually placed one to two feet above the bottom of the vat.

CHIP CELLAR.

CHIP CASKS.

Chips casks are used as receptacles for the beer while it is being clarified and given sufficient carbonic acid or life.

They are generally built of quarter-sawed oak, and are usually barrel-shaped in form, although some have straight tapering sides and others a cylindrical form, the latter being supplied with hoops having a clamp tightening device. Large chip casks are strengthened so as to prevent outward bulging or blowing out of their heads by having the two heads connected or stay-bolted with iron rods or bolts.

Chip casks are sometimes built in shape like stock tubs, but are then made of thicker wood and with more hoops so as to resist greater internal pressures.

Cask Manhole Doors. In barrel-shaped casks the manhole doors are usually about 12 inches wide by 18 inches high. The door has edges tapering outward, so as to fit into a correspondingly beveled opening in the head of the cask when placed against it from the inside. The door is further fastened by means of a block of wood placed outside and long enough to fasten against the staves on both sides of the manhole, the door being tightened to the block by means of a screw bolt. The joint between the door and the cask is made tight by applying tallow on the rim of the door before fastening it.

Cask Supports. The common form of support consists of wooden or I-beams, or steel rails holding a wooden block, which is hollowed out so as to conform to the curve of the cask and prevent it from rolling.

Another simple and efficient form is the ball and socket supports. It consists of a cast-iron foot or base, having a flange at the bottom, where it rests on the floor, and another at the top, upon which the cask rests. This support consists of two pieces, connected by means of a ball and socket joint which allows the upper flange to move in any direction and conform to the shape of the cask.

GLASS ENAMELED CHIP CASKS.

This form of chip cask has been recently introduced.

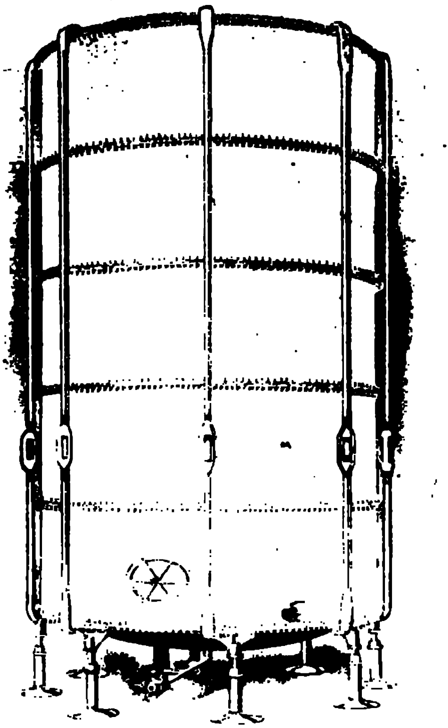
The tanks consist of a series of shallow rings, each 30 inches high, having flanged edges, by means of which they are bolted together so as to make the cylinder of the tank. These rings are surmounted, top and bottom, with dished enameled heads and are further strengthened by means of reinforcing bars running from top to bottom. (See illustration.) The rings are made of finest quality sheet steel, having a very high tensile strength.

Both the outside and inside of the rings are covered with a coating of glass-like enamel or glaze applied by means of high heat so as to insure superior tenacity and adhesion to the steel.

The tanks are supplied with the necessary fittings, which are made either of copper or bronze, and designed so as to be easily cleaned. These fittings include manhole doors, outlet, inlet, racking and try cocks. The legs or supports present a special feature, in that they are made similar to jack-screws, so as to conform to any unevenness of floor. The packing between the

consist of prepared cotton webbing, saturated with water-
compound.

: advantages of using these enameled metal tanks are:
of cleaning, since the inside of the tanks presents an even



Glass Enameled Chip Cask. (Reinforced Tank)

'e of glass-like smoothness and hardness; saving of space;
away with the laborious and dangerous operations of
hing; capacity of withstanding higher internal pressures;
mum necessity for repairs, and finally, almost indestructibility
perly handled.

BUNGING APPARATUS.

This device is used to enable a certain desired pressure to be maintained on the surface of the beer in the chip cask by automatically blowing off any excess pressure created.

The simplest form of bunging apparatus consists of an air tank supplied with a blow-off valve which can be regulated to different pressure. To this tank each chip cask is connected by a hose.

A more modern device consists of an intricately constructed blow-off apparatus having an adjustable dial indicator. Another part consists of an automatic valve screwed into the chip cask whose construction is as follows: This cock or valve has two openings, one for connection with the pressure hose, and the other for connection with the blow-off device. The opening to the blow-off valve is supplied with a check valve arrangement, consisting of a ball tightly fitting over an opening. As long as the pressure in the cask is less than the back pressure from the other casks, or, in other words, the bunging pressure, this back pressure holds the ball in position. But as soon as the pressure in the cask becomes a trifle greater than this back pressure, it forces the ball upward and the gas causing the over-pressure is blown off with that of the other casks. In this device it is unnecessary to connect the hose to the bunging apparatus when the cask pressure becomes sufficient, or to disconnect the hose each time before racking, consequently the bunging hose can always be kept in position. The shutting off of the racking pressure, so as to prevent it from communicating to the bunging tubes, is done by means of an extra cock supplied for that purpose.

Other styles employ mercury seals to regulate the blow-off pressure.

FILTERS.

Beer filters are used for the purpose of clarifying beer, that is, mechanically removing or straining out solid particles, such as hop-resin, albumen, yeast cells, etc., contained in the beer, whereby the time of storage in chip cask, the time for finishing the beer, and the amount of finings are considerably reduced. The use of a filter also reduces "rest" beer and other incidental losses.

The substance used as a filtering material or filter mass is *almost universally cellulose* or pulp prepared from wood or cotton *fibers.*

[redacted]

Modern filters, in order to present as large a filtering surface as possible, consist of several filters combined into a battery, all being contained in one vessel or receptacle. This is accomplished by placing a succession of layers of filter mass at a certain distance from each other, each clamped between two sheets of perforated metal or wire gauze, and then clamping the whole series into one drum or cylinder-shaped receptacle. The supply of fluid is so fed through branches that a portion of the liquid passes through each layer or cell, and all portions are united just previous to leaving the filter.

Another style of filter has round metal dish-shaped plates, containing the filter mass, and these plates or cells are placed in a cylindrical vessel, somewhat larger in diameter than the plates. The whole is then filled with beer which passes through the mass and leaves it through an opening at the center of each disc, the whole number discharging into a central tube or column, wherein the beer is collected before passing out of the filter.

All styles of filters have a "lantern" and gauge at both entrance and discharge inlets to allow inspection of the flow of beer, the degree of brilliancy and pressure on the fluid.

Before the filtering operation can proceed it is necessary to remove the air from the filter, as otherwise the inflowing beer would foam by coming in contact therewith. This is accomplished by first running water through the filter and in turn displacing this water by the beer to be filtered. At the end of the operation the beer in the filter can again be displaced with water and the last beer in the filter thereby obtained for use.

Should it be desired to interrupt the filtering operation until a later time, the filter can be washed by passing water through in the direction of the flow and then backward, repeating this again and again, until the water runs clear both ways, then letting the filter stand full of water, and proceeding with filtration as at the start. This is preferable to the custom of some brewers of letting the filter stand full of beer until used again. Another precaution to be observed during the filtering operation is to tap the cask properly so as not to cause any agitation of the beer with subsequent rising of the particles that may have already settled. The pressure on the cask should not be too great, as it may injure the cask and cause it to leak.

To have good results with filtering it is quite essential to have an air tank to receive pressure from the air pump, instead of *having direct* pressure.

It is necessary to have a double racking cock when racking off beer through a filter, so as to have an uninterrupted flow.

The capacity of beer filters ranges from 15 to 40 barrels per hour, depending largely upon the size of the outlet of the chip cask and the amount of air pressure that can be put thereon, which ranges from 8 to 20 pounds. The location of the filter is generally below the racking room in order to get a more steady pressure and flow at the racking bench.

Pressure Regulating Pumps. In order to obtain a high pressure on the filter and a lower pressure on the cask special regulating pressure pumps are used. These pumps allow any desired pressure to be put upon the filter while the pressure on the cask can be reduced as low as is necessary to deliver the beer to the pump.

Pressure Regulating Pump.

With a high pressure on the filter, i. e., higher than it would be safe to put upon the cask, the advantage is gained that the filter mass can be packed tighter, whereby better filtration is obtained, and moreover, beer can be run through more rapidly, thus saving time in washing the filter mass and more frequent repacking of the filter.

These pressure regulating pumps are supplied with a regulating device, so that any excess pressure, above that at which the pump is set, will be automatically blown off. Such excess pressure is apt to be caused by the filter mass becoming clogged.

In order to filter out albumen, etc., which might precipitate if the beer was subsequently subjected to a temperature lower than that at which it went through the filter, a cooler is inserted in the run before the beer enters the filter. The low temperature in

[redacted]

this cooler precipitates these substances beforehand, so that they can be taken out by the filter.

Filter Mass Washers. In order to enable the filter mass to be used again it is necessary to remove the beer and substances filtered out that remain in the fiber after the beer has passed through.

This is done by means of washing devices that consist of a vessel containing revolving agitators, arms and a clean water inlet at the bottom. The washer is filled with cold water, the pulp put in, and the water supply turned on. The stirrers serve the purpose of keeping the mass well separated, so that the inflowing water will readily mix with the mass and wash it out.

At the top where the water overflows there is usually a straining attachment to intercept the mass that the water has a tendency to carry away.

Other forms of washers consist of a tank containing a perforated revolving drum in which the filter mass is placed.

RACKING MACHINES.

The racking of beer by the old appliances, that is, through an ordinary cock or Y with attached gut, is rapidly being succeeded by the employment of back-pressure filling machines.

By the old method considerable of the carbonic acid contained in the beer is allowed to escape, since the beer runs from the cask, where it is under considerable pressure, into the package in a comparatively small stream at ordinary or atmospheric pressure, allowing considerable of its contained gas to escape, owing to this sudden reduction of pressure. In order to prevent this loss of gas by any sudden reduction of pressure racking devices are constructed which enable the original pressure, or a greater one, to be maintained upon the surface of the beer during the entire time required for filling, and practically also while the package is being closed.

The method of operation of most styles is on the following principle, the differences being mainly in the construction of the several parts: The beer enters through a tube, inserted through the bung-hole of the package, and so applied that it can be raised or lowered by a lever. This tube is supplied with a rubber collar or plug, which is compressible over, or into, the bush in an air-tight manner.

As the beer flows into the package by virtue of the initial

pressure, the air in it is displaced and passes into a special receptacle supplied with a blow-off cock or similar device. The amount of back pressure on the package is thus regulated by means of this blow-off device. Between the filling tube and this reservoir is placed a "lantern" or glass cylinder, for the purpose of indicating when the package is filled. This is readily recognized, since, as long as the air is passing through this lantern it causes white foam to show, which disappears when the beer passes through. At this point the supply cock and cock to reservoir are simultaneously closed the filling tube raised or removed, and the package closed.

These machines are usually constructed with two or more filling tubes, so that as soon as one package is filled the supply and the return from the reservoir immediately flow into another package and the filling is thus carried on continuously.

CARBONATORS.

These devices are used for the purpose of charging stock or "ruh" beer with the carbonic acid gas necessary to give it proper life.

The principle of operation of most carbonators allows either a stream of beer to come in contact with liquid carbonic acid at a high pressure, or forces the beer into a tank, where the gas reaches it and is taken up by the beer. The pressures of both beer and gas and their relative pressures to each other vary in different systems.

One style of carbonator on the market consists of a cylinder for impregnating the beer and another smaller one, or "lantern," for regulating the gas inflow. Both cylinders are connected at their tops as well as at their bottoms, with tubes. The lantern is placed upon a movable arm or lever, and connected with the gas cock in such a manner that as the lantern rises or descends, according to the amount of beer contained, it regulates the inflow of the gas. By suitably counter-balancing the lever arm different regulations are obtained.

Another style consists of a cylinder containing revolving paddles and agitating the beer during impregnation. The regulation of the beer and gas is automatically accomplished by means of a float.

In still another style the beer and gas are run together under

equal pressure in a continuous manner, through a series of coils uniting again into one discharge pipe.

Some systems for carbonating comprise, besides the impregnating devices, a complete system for collecting, purifying and compressing the gas.

WOODEN BUNGS.

Bungs for brewers' use, although very simple in appearance, nevertheless require great accuracy and uniformity in their construction. They are made from choice poplar wood and compressed across the grain. The thickness is usually somewhat less than an inch, and the size commonly used in the United States is 1 15-16 inch diameter. They are first cut cylindrical in shape and then compressed at one end so as to enter the bushing easily.

The bung becoming moist by contact with the beer, expands, and fits more tightly than at first, for which reason slight leaks that appear directly after bunging often disappear soon afterwards.

Wooden bungs, although almost in universal use, present the drawback, that, in the closing of the package a blow of considerable force is necessary properly to seat the bung. This may loosen the bushing, and cause subsequent leakage, or may crack off part of the interior lining of pitch, if such happens to be somewhat brittle.

MECHANICAL BUNGS.

They consist of two or more metal parts covered with, or connected by, a rubber housing or disc. By means of an eccentric motion these metal parts are either spread or compressed, whereby the rubber portion is widened or expanded so as to fill the bushing while in the compressed state. This is done by means of a key of special construction, so that the bung cannot be removed except by a person possessing such a key. They should not, however, possess the defect that the opening in the bung gets clogged with ice or dirt and prevents the insertion of the key and quick removal of the bung.

Another style of mechanical bung is built upon the check valve principle, the internal pressure affecting its closing. In tapping, these bungs require a special faucet to fit so that only the possessor of one of these can tap the package. The connection between faucet and bush is so constructed as to avoid loss of contents while tapping.

BUNG EXTRACTORS.

The extraction of wooden bungs from returned packages is generally a time-consuming operation, especially so when chips or pieces of the bung happen to fall inwards.

In order to meet these drawbacks a special machine for this purpose has been put on the market. It consists of a revolving shaft, supplied at one end with a specially constructed auger, and the whole mounted upon an iron stand. In front of this is placed another stand or rest, upon which the packages rest. A raising and lowering device allows packages of different sizes and diameters to be placed so that their bungs will be at the same height as the auger.

Another advantage of this machine is that neither the pitch in the package nor the bushing is loosened during the operation. In fact, any bushing that may be loose will be tightened while on the machine, since the revolution of the auger is in same direction as the bushing thread.

BRANDING DEVICES.

Every package that leaves the brewery should be indelibly marked with the name and address of the brewer. The method adopted for marking consists in burning these marks into the wood.

This is done by means of a die having raised letters or type. The die, or brand, as it is called, is heated in a fire and pressed against the package, whereby the raised parts of the brand will burn their way into the wood.

As this method of heating and branding is slow in operation and also gives uneven results, devices are in use where the brands are continuously heated, saving the time otherwise lost between the heating and the application of the implement.

These styles of devices are made with either one or two branding dies. In the single style, the brand is attached to a descending lever, whereby it is pressed upon the head of the package underneath.

The double style has two branding dies placed on upright levers, one for each end of the package, and connected to each other with a right and left screw. The package is placed upon a support between the branding dies, and by turning the screw both brands are forced towards each other and against the heads of the package. An opposite turn of the screw removes them.

The heating is generally done with gasoline vapor or illuminating gas, burned by mixing with air in a specially constructed Bunsen burner.

BUNG BRANDS.

Of late many brewers are branding their wooden bungs with the date on which the beer was racked or filled into the package. This gives them an excellent control over shipping beer, since the bung is not disturbed or removed from the package and returns with it to the brewery with the branded date still intact.

The brewer can, therefore, immediately see on what day the beer was racked, and may know from what lot or cask it was taken, and how long the package was away from the brewery. This gives him positive information, often enabling him to settle controversies and disputes with his customers quickly and in his favor.

The operation of branding bungs is very rapid and it takes but a short time to brand enough for a day's supply.

Bungs are branded on either side, usually on the outside, although some brewers prefer the inside, as there is then no possibility of the mark being effaced.

The machines for branding bungs employ small brands heated by gas, similar to the larger package brands.

WASH-HOUSE, ETC.

After the packages are returned to the brewery they must be washed thoroughly and examined for leakage and condition of the pitch coating, etc.

The condition of the pitch can be readily determined by an experienced man by inserting a light into the package and examining its inside surface.

The washing of the packages was until recently a laborious operation, each package being handled separately, soaked, brushed, rinsed, etc. But automatic devices are now in use which soak, convey, scrub and rinse packages with very little labor.

These apparatus consist of a long narrow soaking tank, into which the packages are placed. Here they are either pushed along by hand or conveyed mechanically. The conveyors either run through or above the tank.

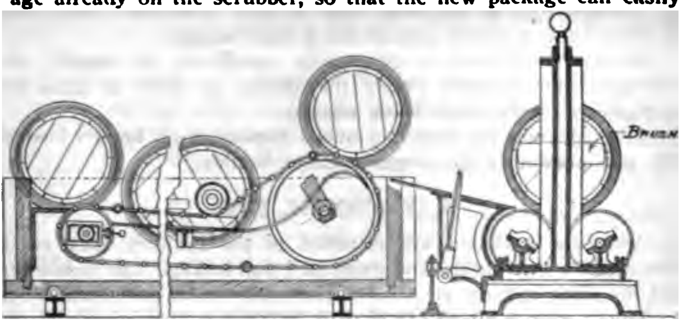
The submerged style carries the packages, while the external style *pushes or rolls* them by means of an arm extending down

ward from the conveyor. After the packages have arrived at the other end of the tank they are placed upon the scrubbing machine, some machines delivering them automatically.

The water used for soaking should be as warm as the pitch in the package can stand without softening.

The scrubbing machine consists of an iron frame holding at its lower part two revolving shafts on which are fixed four iron or rubber wheels. Upon these wheels the package rests, and these shafts and wheels being revolved, the package also revolves, and scrapes between and under a set of brushes attached to the sides and upper parts of the frame of the machine, whereby all external dirt, etc., is removed.

As the package from the soaking tank is discharged towards the scrubbing machine it rolls over and depresses a lever or tripper, which spreads the brushes and elevates the washed package already on the scrubber, so that the new package can easily



Soaking Tank and Keg Scrubber.

fall into position. In doing this the new package dislodges, by concussion or bumping, the washed package, the former position of which it then occupies.

After the lever is released the brushes are again forced together and press tightly upon all the surfaces of the revolving new package.

This lever in some styles of machines automatically turns on the water supply necessary for the scrubbing operation, the latter issuing in a spray over the surface of the package.

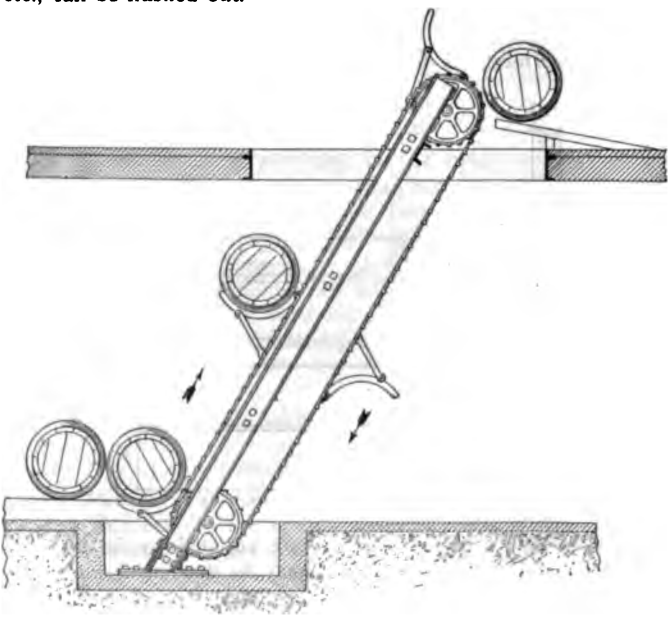
KEG SPRINKLERS.

After being scrubbed the packages are placed over and upon *a sprinkler or rinser* which injects, under pressure, a spray of

clear water into them in order to remove the last traces of soaking solution, etc., from their insides.

The final rinsing water should be pure, as part remains in the package by adhesion and eventually comes in contact with the beer.

The packages should also be placed over this sprinkler before entering the soaking tank, as thereby much of the beer remnants, etc., can be flushed out.



Keg Elevator.

KEG ELEVATORS.

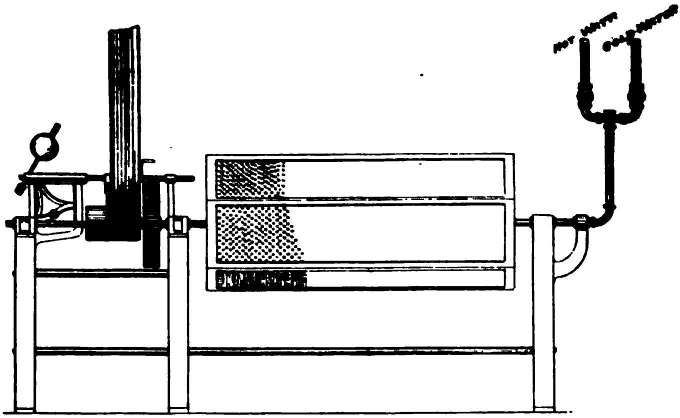
In order to raise filled packages from one floor to others above, or to the loading platform, keg elevators are used.

They consist of an endless chain running over two sprocket wheels, and placed either in an upright or slanting position. Attached to this chain, at intervals, are iron arms for the purpose of lifting the packages. Close to the ascending chain a lattice *work or slotted platform* is placed, allowing the arms of the el

vator to pass through it freely. All that is necessary to elevate a package is to roll it upon this platform, where it remains until the ascending arms grip, raise and again discharge the package when it has passed over the top wheel, in which position the arms are above the package. In fact, the whole system of operation is the same as that of the endless belt bucket conveyor.

SHAVINGS WASHER.

This consists of a differently shaped perforated drum, revolving in either direction, and supplied with a central hollow shaft or tube with perforations for sprinkling water into the drum.



Shavings Washer.

As the drum revolves the chips are agitated by falling, and a spray of cold or warm water, as may be desired, is run upon the chips to remove or wash off the yeast and other matter.

PITCHING, AND PITCHING APPLIANCES.

In order to prevent wooden receptacles from absorbing part of the contained liquid within the pores of the wood, which would afterward, when they are empty, result in souring and possible infection when the package was filled again, such wooden vessels receive an internal coating of an inert substance. In open vessels, or such as can be entered by a workman, this coating usually consists of varnish, mostly shellac, applied with a brush, but in smaller ones, where this procedure is impracticable, the practice

is to flood or coat the inside of the vessel with a substance which readily melts at a temperature not affecting the wood, while it does not impart any taste to the beer or other fluid, and is easily applied, since it must be often replaced.

The substance found to be best adapted to this purpose is pitch. (See Brewing Materials).

New packages are treated by first heating the inside of the package in order that the injected melted pitch may be able to flow evenly over its entire inner surface before cooling, while in packages already coated the old coating must be first removed by similar internal heating before the fresh coating can be properly applied.

THE OLD METHOD.

To accomplish these purposes in the older methods, either hot air, that is, air that has been passed through a bed of live coal or coke, or superheated steam, or both, are injected into the package. In so doing, however, care should be taken not to burn the wood around the bung-hole. After the old pitch is removed a measured quantity of molten new pitch is injected into the package, which is then closed with wooden plugs and rolled or turned in order to spread the pitch evenly over the inner surface. Finally, any excess of pitch not adhering to the wood is allowed to run out.

The pitch is usually melted in an open iron kettle, heated with coal.

PITCHING MACHINES.

One form of automatic pitching machine consists of a receptacle for heating the pitch, connected with which is a separate chamber holding the measured quantity of pitch necessary to pitch the package.

Another style consists of a kettle, at the top of which a hand pump having a spray nozzle is attached for the purpose of injecting pitch into the package.

A style of pitching machine that has given good results and is in quite extensive use has the following construction: A two-inch steam pipe leads from a boiler to the pitching machine, which may be a distance of 300 feet, if necessary. The steam enters the jacket on top of the furnace, is superheated there, and so enters the blower, drawing with it hot air from the jacket covering the furnace top. The combined heated air and steam is forced through the grates and fire into the barrels for the pur-

pose of melting out the old pitch. No way of stopping the egress of steam is given in order to do away with the danger of explosion. In another form the pitch is injected into the package by means of air pressure upon the surface of the pitch, while in another kind the pitch is removed in one part of the apparatus, and the package then taken off and placed upon another part, where the new pitch is injected.

All the above described machines require two operations, viz., removing the old pitch and applying the new, and usually a third operation, viz., rolling the packages to get an even distribution of the pitch. This requires time and labor, and it is not an uncommon scene to see quite a number of workmen engaged in the pitching and rolling operation.

COMBINATION PITCHING MACHINES.

In order to reduce the labor to a minimum, machines are on the market which require one man only for their operation and in which the packages are stripped of the old pitch and a new coating applied in a single operation.

SPRAYING MACHINES.

The main features of these machines are as follows: The package is placed on the machine with the bung-hole over a spray nozzle, and the flow of pitch turned on, whereupon the pitch is sprayed into the package, striking the entire inner surface. This causes the old coat to melt off, flowing back into the tank, while a new coating is left in its stead. The flow is then stopped, and the package, after the superfluous pitch has run out, is taken off the machine in a finished state. One man can readily run this process, and rolling of packages is unnecessary with the use of these combined or double-acting machines.

The machines of this type, however, differ from each other in general construction and the means employed to deliver the pitch to the package.

In one style, the pitch is thrown into the package by means of a centrifugal pump sucking the pitch inward and forcing it out through the nozzles. Here an ingenious movement is used; by raising a handle the nozzle is at the same time raised into the package and the flow communicated through it. Simultaneously with this operation a worm gear is connected, and the spindle or spray tube and nozzle are revolved as long as the

handle is raised. Both flow of pitch and motion cease when the handle is depressed.

Another style of machine likewise employs a centrifugal pump, but has a novel device which obviates any serious consequences possibly resulting from the man in charge forgetting to stop the flow of pitch before he removes the package from the machine. The hot pitch cannot be sprayed around, possibly scalding the operator seriously. This safety device consists of a balanced arm, to one side of which is attached a plunger operating a pump in the pitch below. At the outer end of this arm is placed a counterweight somewhat lighter than the package to be pitched. By placing the package in position it drops over the spray nozzle and depresses the side of the arm, and by the same motion the descending plunger opens the flow of the pitch to the package. When the package is raised, which is necessary in order to remove it, since the spray nozzle extends into it for some distance and the package cannot be pushed off sideways, the counterweight raises the package support and by this opposite motion in turn automatically shuts off the flow of pitch.

The other styles of these combination machines differ mainly in the general construction of parts or in the method of applying the power for injecting the pitch. In some styles this is done by means of compressed air acting upon the surface of the pitch in the kettle. The spray nozzle in all styles consists either of a stationary perforated bulb for sprinkling the hot pitch in all directions, or of a revolving slotted bulb ejecting the pitch in a thin revolving sheet. In either style the pitch strikes all of the inner surface of the package with some force, whereby the old coating is melted and rinsed out, running back into the kettle, and is replaced by a new coating.

With these double-acting machines one man can run a four-spindle machine by so regulating the placing of the packages that as soon as one is placed another is ready for removal. The packages must, however, be delivered to him and taken away, which usually requires the services of another workman or helper.

After the packages are pitched they are filled with water for some time, in order to displace any pitching gases and to dissolve any soluble substances which would otherwise be dissolved by the beer and might affect its quality.

BREWING OPERATIONS.

INTRODUCTORY.

In the following are given the principles and methods of brewing, as they are understood and recommended by the American Brewing Academy, as well as the Scientific Station for Brewing of Chicago. The matter is presented in a very concise manner, in accordance with the plan of this book, refraining from all discussions and omitting all subjects that do not appear to have practical significance. Readers will find in other parts of the book matters pertaining to Brewing Science, theoretical, historical and explanatory.

As far as Brewing Operations are concerned it seemed to the publishers essential to have the subject treated from one standpoint, so as to avoid confusing the reader, who is not supposed to study this part with a view of drawing his own conclusions, but rather of obtaining advice. If, therefore, statements are made which, in the light of the present status of brewing science, must be considered to be still in doubt, the reader will remember the reasons that prompted an avoidance of discussion at the respective place. For the same reasons it was found undesirable to make extensive mention of literature in this part of the book.

GENERAL OUTLINE.

Brewing Operations, properly so-called, embrace the production of the wort from the raw materials. They include all the operations from the scouring or cleaning of the malt up to the point when yeast is added to the finished wort in the settling tank or the fermenting vat.

Before selecting and weighing the materials, in order to start *brewing operations*, the brewer should clearly understand the *requirements the finished* product is to meet, and every operation

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he carries out should be undertaken with a knowledge of the influence it may have in shaping the character of the beer as desired.

Beers as we find them in the market vary greatly as to their properties. We may distinguish, for instance:

1. The *Bavarian* type of lager beer, with a dark color, malt flavor, and a sweetish taste as the main features, with the aroma and bitter taste of hops but little pronounced; usually lively and sparkling.

2. The *Bohemian* type of lager beer, with a light color, pronounced hop aroma, and bitter taste; while the malt flavor is not pronounced; usually lively and sparkling.

3. The *American* type of lager beer, with a light color and pronounced hop aroma; less bitter than the Bohemian, with a high degree of brilliancy; quite lively and sparkling.

4. *Ale,* with a light color, very pronounced hop aroma and bitter taste, and with a rather high percentage of alcohol and tart taste in the aged product, either lively or still, and usually clear.

5. *Stout,* with a very dark color, malt flavor and sweet taste, brewed stronger than ale, and possessing a tart taste in the aged product, but less alcohol than ale; usually lively.

6. *Weiss beer,* very light in color, no pronounced malt or hop flavor, quite tart, very lively, but not sparkling; usually turbid.

7. *Common or Steam Beer,* light in color, hop aroma and bitter taste not very pronounced; very lively and not necessarily brilliant.

The American, Bohemian and Bavarian types of lager beer should possess a certain degree of palatefulness, and should draw with a creamy, lasting head, which requirements are not to the same extent to be met by the other brands.

Besides the above there are brewed in America beers to meet special requirements, for instance:

Temperance beers, so-called; bottled goods, with a percentage of alcohol less than 2 per cent. Such beers are considered non-intoxicating, and are not excluded from the market in so-called temperance districts.

Tonics, so-called: Bottled goods brewed with a high percentage of extract, usually pure malt beers, possessing a dark color, either thoroughly fermented with a high percentage of alcohol and comparatively low percentage of remaining extract, or im-

perfectly fermented, with a low percentage of alcohol and high percentage of remaining extract.

The selection of the methods to be employed to produce beer should be made from the point of view of quality, that is, character, of the finished product, and from the view point of economy.

PROPERTIES OF A BEER.

The character or properties of a beer are necessarily dependent upon its composition, that is, upon the amount and nature of certain substances contained in the beer, and although we may not as yet be able to account chemically for every peculiarity of character a beer may possess, it seems justifiable to express the well-known properties of beer in terms of concrete chemical substances.

Such properties of beer are:

"Palate-fulness (body)," dependent upon the relative amounts of extractive matter, especially albuminoids (albumoses, peptones, amides).

"Foam-holding capacity," dependent on a definite amount of carbonic acid gas, and on the same substances that give palate-fulness.

"Life," dependent on amount of carbonic acid.

"Color," dependent on amount of caramel.

"Malt Flavor," also dependent on amount of caramel.

"Hop Flavor," dependent on amount of hop-oil.

"Taste:" "Bitter," dependent on amount of hop resin; "sweet," on amount of sugar (kraeusened beers) and malto-dextrin; "tart," on amount of lactic acid; refreshing taste, on amount of carbonic acid.

"Stimulating effect" on consumer, dependent on amount of alcohol.

"Brilliancy," by which we mean the property of a beer of being transparent. Brilliancy may be impaired by particles in suspension, which may consist of either complete organisms or organic matter. The former may be either yeast cells, and in that case culture yeast, wild yeast, or mycoderma; or, bacteria, under which head come sarcina, lactic acid ferments, butyric acid ferment, acetic acid ferment, saccharobacillus pastorianus. The *organic matter* may consist of starch, albuminoids, or hop resin. *Inorganic matter is* found in rare instances as a cause of turbidity.

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"Durability (stability)," by which we mean the property of a beer of retaining its character after it is finished. This property may suffer from yeast cells, bacteria, or albuminoids, or any condition favorable to the growth of yeast or bacteria, like presence of sugar, or storing at high temperatures. It is enhanced by the amounts of alcohol, carbonic acid, lactic acid, and hop-resin, which have the force of natural preservatives.

COMPOSITION OF BEER.

The substances that make up beer, varying in ratio according to the character of the beer, are:

Non-volatile: 1. Albuminoids, divided into albumoses, peptones, amides, all of which are desirable, and proteids, which are undesirable. 2. Carbohydrates, as dextrin, malto-dextrin, maltose. 3. Miscellaneous bodies, as lactic acid, mineral substances, hop-resin, and caramel.

Volatile: Alcohol, carbonic acid, water and hop-oil.

BEERS CLASSIFIED.

The composition of a beer is dependent upon the composition of the wort from which it has been produced, on the method employed in fermentation, and on the treatment of the beer after fermentation. According to the system of fermentation employed, beers may be classified as follows:

1. BOTTOM FERMENTATION.

a.	*Pilsener*	German Lager Beers.
b.	*Wiener*	
c.	*Muenchener*	
d.	*American Lager Beers.*	
e.	*American Steam Beers.*	

2. TOP FERMENTATION.

f.	*Ale*	English Beers.
g.	*Porter*	
h.	*Stout*	
i.	*Weiss Beer.*	

3. SPONTANEOUS FERMENTATION.

j.	*Lambic*	Belgian Beers.
k.	*Faro*	

The influence of the system of fermentation on the composition of the beer becomes noticeable, especially in the different quantities of lactic acid produced during fermentation and storage

Bottom fermentation beers have less lactic acid and fewer bacteria than top fermentation beers, these, in turn, have less than spontaneous fermentation beers.

WORT.

The term "wort" is applied to the fluid produced by the process of brewing proper from the raw materials and before its transformation into beer by fermentation. As to where the fluid ceases to be wort and begins to be beer, no hard and fast line has been established. The materials from which the wort is made are malt and malt adjuncts, hops and hop preparations, and water.

INGREDIENTS DERIVED.

The ingredients of the wort are derived as follows:

Dextrin .... Malto-dextrin .. Sugar	from starch by action of diastase..............	Enzymes generated in barley by malting.
Amides .... Peptones ...... Albumoses ..... Proteids	from albumen of malt by action of peptase......	
Caramel—formed from sugar in kiln-drying of malt.		Extracted by water.
Lactic acid—formed during germination by action of lactic acid ferment and at low temperature in mash.		
Mineral substances—from malt or adjuncts to malt.		
Hop oil .... Hop resin	from hops.	

PRINCIPLES OF MASHING.

Mashing is the process of extracting the goods by mixing them with water at suitable temperatures and in proper relative quantities, preparatory to boiling in the kettle.

Chemically, it proceeds in the main by the inversion of the starch into maltose, malto-dextrin, and dextrin, and the modification of the insoluble albuminoids into a soluble form. These changes are brought about by the agency of two substances which are contained in the malt, and begin operations when the malt is mixed with water at definite temperatures.

These substances are called diastase and peptase. They were *formerly called* chemical ferments as distinguished from the or-

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ganic ferments which are responsible for fermentation. At the present day the term enzymes, or soluble ferments, is more commonly applied to them. It is the function of the diastase to invert the starch, of the peptase to modify the albuminoids of malt. as above indicated.

The amounts, both absolute and relative, of dextrin, maltodextrins and maltose, as well as of the modified albuminoids like albumoses, peptones and amides, finally present in the wort, are materially affected by the conditions under which the enzymes do their work. Hence, it is in the power of the brewer to control the composition of the wort, within certain limits, by modifying such conditions.

DIASTASE AND STARCH.

(See also Chemistry.)

Diastase is a body having many properties in common with vegetable albumen of the type of proteids. It is readily soluble in water. A solution heated to 178° F. (65° R.) precipitates, like proteids, flakes of albumen, the diastase coagulates and loses its power of inverting starch. A solution of diastase, upon being introduced into starch gelatinized by heating in water, liquefies the starch, and then inverts it into dextrin, malto-dextrins, and sugar. Inversion is most rapid between 122° and 140° F. (40° to 48° R.). As the temperature rises up to 167° F. (60° R.), the inversion of starch proceeds more slowly, its action practically ceasing at 178° F. (65° R.), the ratio of sugar declining, and that of dextrin increasing above 140° F. (48° R.).

Below 122° F. (40° R.) the energy of diastase declines more and more, but remains to some extent even at 32° F. (0° R.). This fact is utilized for the purpose of clarifying beers in case of starch turbidity by adding malt extract.

Diastase acts but slowly on starch that has not been gelatinized. Gelatinization must therefore precede inversion.

GELATINIZATION OF STARCH.

Starch being mixed with water, and the mixture heated, at a certain temperature the starch granules begin to swell and finally burst, and a gelatinous mass or starch-paste results. For crushed malt, this process goes on rather slowly in the mash at temperatures between 122 and 144° F. (40-48° R.), and more rapidly as the heat approaches 167° F. (60° R.), while it is quite insignificant *under 100° F. (30° R.).*

RULES FOR GELATINIZING STARCH.

The following general rules can be given for the gelatinization of starch when brought together with water.

1.—The higher the temperature, the more quickly will the starch gelatinize. In boiling water (212° F.) the starch will gelatinize, for instance, more quickly than in water of 167° F. (60° R.), and in water of 250° F. (97° R.)—when heated under pressure—more quickly than at the boiling point.

2.—The more finely divided the starch, the more quickly will it gelatinize. Corn meal will gelatinize more quickly than coarse grits at the same temperature; corn flour more quickly than corn meal.

3.—The more flinty the starch, the slower will it gelatinize. The starch in crushed malt will gelatinize more quickly than the starch in corn meal of the same degree of fineness, the starch in corn meal being more flinty.

In malt we have the starch, generally speaking, in different degrees of mellowness and fineness. Some of this starch will be readily soluble at comparatively low temperature, i. e., between 122 and 144° F. (40-48° R.), while the coarser and more flinty particles need higher temperatures for gelatinization; the diastase acting practically only upon gelatinized starch. The time required for complete inversion of the starch depends upon the rapidity of gelatinization and upon the energy of the diastase at certain temperatures. Thus, although at 133° F. (45° R.), the energy of the diastase is very great, the diastase inverting the gelatinized starch almost instantaneously, complete inversion is not so quickly attained, in a malt mash, for instance, at this temperature, as it is at 167° F. (60° R.), where the energy of the diastase is greatly diminished, but the rapidity of gelatinization much increased.

The time required for the complete inversion of the starch in a malt mash, when kept at certain temperatures, has been found to be:

At degrees F.	100	122	140	149	158	167	176
At degrees R.	30	40	48	52	56	60	64
Time for complete gelatinization and inversion in hours	No complete inversion obtained.	24	6	1	¾	1	2

The time will, of course, vary with the character of malt, no *two mashes giving* exactly the same figures.

[redacted]

When holding corn meal at various temperatures, gelatinization has been found to proceed as follows:

At degrees F..	30	122	150	190	212	300
	none.	very slow.	slow.	more rapid.	rapid.	very rapid.

INFLUENCE OF DIASTASE ON GELATINIZED STARCH IN RESPECT TO PRODUCTS FORMED.

Diastase acting upon gelatinized starch transforms or inverts this substance into other products, of which the important ones are the different forms or types of

Dextrins,
Malto-dextrins,
Sugars.

DEXTRINS.

(See also "Chemistry.")

The "amylo-dextrin" and "erythro-dextrin" are undesirable. They are not soluble at low temperatures and give rise to so-called starch turbidities when present in the beer.

The desirable type among dextrins is the achroodextrin, which is the one commonly designated as dextrin.

The dextrins are practically unfermentable by culture yeast, and are found in the extract of the beer in the same amount as contained in the wort.

SUGARS.

Of the different types of sugars contained in wort, the one known as "maltose" is the most important. Besides this, small amounts of saccharose (ordinarily termed cane sugar) and dextrose (ordinarily termed grape sugar) and levulose (ordinarily termed fruit sugar) are also present.

All these sugars are readily fermented. Their amount determines the percentage of alcohol in the fermented beer, and the degree of fermentation.

MALTO-DEXTRINS.

The malto-dextrins represent substances that may be considered as in a state of transition from the dextrins to maltose. They do not ferment with the same facility as the sugars, and are not found in the fermented beer in their entire quantity like the dextrins. They are called the "not readily fermentable" sugars. Some species of yeast, the so-called high-fermenting types, ferment these malto-dextrins more readily than others, the so-called low-fermenting types.—(See also "Yeasts and Fermentation.")

PROPORTIONS OF DEXTRIN, MALTOSE AND MALTO-DEXTRINS.

According to the conditions under which inversion takes place, which are mainly those of temperatures and periods of action, the proportions of these different carbohydrates to each other may vary considerably.

At temperatures where the diastatic energy is not weakened there is a tendency to form more maltose and less dextrin than at temperatures where the diastatic energy has become affected by high heats. Thus below 140° F. (48° R.) the proportion of maltose to dextrin is greater than above 140° F. (48° R.), and the higher the temperature is selected for inversion above 140° F. (48° R.), the greater will be the relative amount of dextrin.

The diastase continues to act on the dextrins and malto-dextrins already formed, changing them to maltose. The longer the mash is held at certain temperatures, the greater will be the amount of maltose in proportion to the amount of dextrin.

The absolute amount of dextrin formed may approximate that of the maltose, but is never found to be higher under the conditions obtaining in the brewery.

The relative amounts of sugar and non-sugar found in the mash, when the mixture of malt and water is held at certain temperatures until inversion is complete, is about as follows:

At degrees F......	100	122	140	149	154	158	163	176-178
At degrees R......	30	40	48	52	54	56	58	64-65
Ratio of sugar to non-sugar 100:..	20	20	20	40	50	60	70	100
Or percentage of sugar in extract..	83	83	83	71	67	62.5	59.8	50

In carrying out the mashing process, therefore, we must consider:

1. That under 100° F. (30° R.), but little starch of the malt is gelatinized.
2. That above 150° F. (52° R.), the starch of the malt is gelatinized rapidly.
3. That below 100° F. (30° R.), little sugar or dextrin is formed.
4. That between 122° F. (40° R.) and 140° F. (48° R.), much sugar and little dextrin is formed.
5. That above 150° F. (52° R.), less sugar and more dextrin is formed than between 122 and 140° F. (40 and 48° R.).

6. That unmalted cereals, containing starch in a flinty state, must be boiled to gelatinize the starch.

PEPTASE AND ALBUMEN.

(See also "Chemistry.")

The action of this enzyme lies in the direction of making soluble those albuminoids which are insoluble in the ordinary state. It acts only upon the albumen of malted cereals, develops the greatest efficiency at about 100° F. (30° R.), and declines in strength when the temperature rises above 133° F. (45° R.):

At degrees F...	32	55-77	100-133	145-158	158-212
At degrees R...	0	10-20	30-45	50-56	56-80
	very slow.	more rapid.	very rapid.	slower.	no action.

SOLUBLE ALBUMINOIDS.

The soluble albuminoids produced by peptase may be classified as proteids, albumoses, peptones and amides, although there must be conceded to be a number of intermediate products.

PROTEIDS.

The proteids are not desirable in wort, and should be eliminated therefrom as far as practicable. The hazy appearance of the wort when running from the mash tub is mostly due to proteids. They are only partially eliminated by boiling the wort, a haze generally, and a strong turbidity sometimes, becoming noticeable when the wort is reduced to the temperature for starting fermentation.

The nature of the proteids found in wort and beer shows considerable differences. From 100° F. (30° R.) to 133° F. (45° R.), proteids are formed that are precipitated easily in the kettle and storage vat, and produce good hot and cold "breaks." The higher the temperature above 133° F. (45° R.) at which proteids are formed, the less desirable their nature. A wort that breaks well after cooling to 35° to 40° F. (3° to 4° R.), or filters clear at that temperature, retains but small amounts of undesirable proteids.

In the finished beer a haze sometimes appears at low cellar temperatures, which vanishes when the temperature is raised; or the beer runs clear at the racking bench and develops a sediment in the bottle after pasteurization. In both cases the cause is in the proteids if the beer is otherwise sound and properly treated.

PEPTONES, AMIDES AND ALBUMOSE.

Albumose, peptones and amides are called desirable albuminoids. They lend foam-holding capacity and palate-fulness, or body, to the beer, especially the amides to a marked degree, the latter supplying also nourishment for the yeast, while the peptones are not readily taken up by the yeast, and the albumoses do not furnish it with any nourishment.

Of the total amount of albuminoids contained in the wort, about 25 per cent or one-quarter is taken up by the yeast under ordinary conditions of fermentation.

Holding the mash at a low temperature—below 133° F. (45° R.)—promotes the formation of desirable albuminoids, whereas a higher initial mashing temperature—not to exceed 167° F. (60° R.)—diminishes the amount of desirable albuminoids and correspondingly increases the amounts of the undesirable proteids.

MASHING METHODS AND CHARACTER OF BEER.

The method of mashing to be followed is determined by the requirements as regards the character of beer, etc., and an intelligent selection of the method to be adopted in order to obtain the desired result can be made only with a full understanding of the principles above laid down.

If it is desired to obtain a beer with a high degree of palate-fulness and foam-holding capacity, the brewer must understand how to incorporate in the wort the desirable albuminoids and unfermentable extractive substances on which these properties depend, at the same time avoiding the undesirable albuminoids where durability is an additional requirement.

This can be done by peptonizing at low temperatures, for instance, 100° F. (30° R.), for one hour, and inverting the starch at higher temperatures, for instance, between 154 and 167° F. (54 and 60° R.), in 30 minutes, and raising the temperature rapidly between 100° F. (30° R.) and 154° F. (54° R.) in 20 minutes to avoid the formation of too much maltose.

If we wish to obtain beers with a very low percentage of alcohol, and a very high percentage of extract, we can do so by starting the mash with a temperature above 154° F. (54° R.) if we do not at the same time require the albuminoids for palate-fulness, etc. If we wish to obtain beers with a high percentage of alcohol, *we should hold* the mash long enough between 122 and 140° F. *(40 and 48° R.)*, at which temperature maltose is mainly produced.

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ECONOMY.

The selection of the proper brewing methods should not be governed altogether by the composition of wort and quality of beer to be produced, but due regard should be had to economy of operation. Especially should it be the endeavor of the brewer to minimize any and every waste, be it of materials, coal or labor.

By waste of material is meant the loss occasioned by insufficiently extracting the materials, especially malt and cereals, thereby allowing too much of the valuable constituents to remain in the grains.

By waste of coal in this connection is meant the loss occasioned by adopting unscientific methods of brewing that call for an excessive expenditure of heat, for instance, boiling the brewing water or the wort longer than necessary, or cooling the wort before the addition of yeast to an excessively low temperature.

TO OBTAIN A HIGH YIELD.

In order to keep down the waste of malt and cereals, the most perfect yield possible ought to be obtained from the materials. Three different operations are essential to accomplish this result:

1. To prepare the starch and the albumen for inversion as completely as possible.
2. To invert the starch and albumen, so prepared, as completely as possible.
3. To extract the grains as completely as possible.

In fulfilling the first requirement, viz., the preparation for inversion, it should be borne in mind that the albumen can be made invertible only by the process of germination of the grain. The starch can be made invertible by the following means and processes:

1. Malting (cereals, especially barley).
2. Crushing (malt).
3. Rolling (cereals with mealy endosperms or starchy part, especially wheat).
4. Grinding (corn, rice).
5. Boiling (corn, rice, flinty malt).
6. Boiling under pressure (corn).
7. Steaming and rolling (corn, by which method corn flakes are produced).

With regard to the second requirement for a perfect yield, viz., the *complete inversion* of the prepared starch and albumen, it is

to be said that inversion should take place in the mash tub at 100-133° F. (30-45° R.) for albumen and 153-167° F. (54-60° R.) for starch.

With regard to the third requirement for a perfect yield, viz., the complete extraction of the grains, this is done by washing out the extract with water (sparging). In order to extract the grains most completely it is necessary to reserve as much water for sparging as possible. Generally the brewer should be able to reserve at least one-half of the water employed for the brew for this purpose.

MASHING OPERATIONS.

The mash should be so conducted as to secure the desired composition of the wort and obtain the largest possible yield of extract from the goods employed.

With respect to securing the desired composition, the conditions which control the ratio of sugar to dextrin and the production of desirable albuminoids should be observed.

With a view of obtaining the full yield which the goods can afford, it is necessary to prepare for inversion, and invert, the starch in the brewing materials, and to wash out the grains, most completely.

It is with an eye to these requirements that the malt should be prepared so as to possess a proper degree of mellowness and friability and no vitreous or flinty quality. Such a malt will afford the mash liquor ready access to all its parts, subjecting them to the action of the enzymes.

The same purpose is served by crushing or grinding the malt, which is always done before running it into the mash-tun. The more mellow the malt, as to consistency, the less fine need the grist be, and, on the other hand, the less mellow the malt, the finer should the grist be.

Where the degree of mellowness is quite low, the crushed malt may with profit be prepared in the rice cooker, with or without raw grain, as it is apt to give rise to difficulties of drainage if put into the mash without preparation. Any malt should be so ground that every single grain is crushed, but not so as to *become pulverized.*

Care should also be taken to remove all the sprouts since they contain many undesirable proteids.—(See "Cleaning Malt" in "*Malt House Outfit.*")

MASHING SYSTEMS.

Different methods of applying temperatures to a mash supply the following systems:

1. Infusion or water mash:
   American Malt Beers.—From lower initial temperature to higher final temperature.
   English Beers.—High initial temperature.
2. Decoction or Thick Mash.—German beers.
3. Double Mash.—American raw cereal beers.

By the infusion method, the mash is brought to its final temperature by the admixture of water of suitably high temperature. By the decoction method, part of the mash itself is raised to a boil and then returned to the mash-tun. By the American raw cereal mash the raw grain is boiled separately and run into the malt mash to produce the final temperature.

Malt contains diastase in quantities sufficient to convert into maltose more starch than that which is stored up in the malt itself. This fact, which was known for many years, naturally led to efforts to put this valuable substance to practical use. Brewing experts, among them Balling, years ago utilized the excess diastase in malt for the purpose of converting the starch of unmalted grain, or raw cereals, into such materials as were useful to brewers, but owing to legal restrictions the utilization of unmalted cereals never acquired any importance in Germany.

American malts on an average possess a much greater diastatic strength than German malts, in fact, their power in this respect is so great that there is danger of carrying saccharification too far, if the mashing temperatures that are customary in Germany were retained. Hence, the principles of raw cereal brewing became the subject of closer study in this country.

INTRODUCTION OF RICE AND CORN.

It was Anton Schwarz who first advised the employment of rice and subsequently of Indian corn, which is so abundant in this country. The stubborn perseverance with which he sought to convert the conservative brewers to his ideas and finally succeeded in so doing and, last, not least, the discovery of suitable methods for scientifically applying them, entitle him to be called the founder of raw cereal brewing in the United States.

The method suggested by him was based upon the plan

doughing-in the raw grain with a little malt in a separate vessel, making the starch of this raw cereal as nearly as possible entirely soluble by boiling, and running this mash into the malt mash, thereby raising the temperature of the latter to the desired degree, and utilizing the excess diastatic strength of the malt for the complete inversion of the starch in the raw cereals.

It was soon discovered by the brewers that the use of raw cereal adjuncts not only gave a paler color, greater stability and other valuable properties to the beer, but also enabled beers to be produced more cheaply, and its adoption speedily became general. Schwarz never advised using too much raw cereal, but rather opposed it. One-third of the materials figured for malt seemed to him quite sufficient, for with this wise restriction no injurious change in taste need be feared. He also successfully opposed the erroneous opinion that raw cereal worts required more hops than all-malt worts, whereby the saving would be about neutralized.

In 1881 Siebel wrote a treatise (Verbrauen von Rohfrucht, Western Brewer, 1881, page 1463) on the employment of malt adjuncts, like corn, rice and sugar, from which it appears that the methods then employed in the treatment of corn remained subsequently practically unchanged until the introduction of the pressure cooker.

PREPARED CORN.

The increase in plant from the necessity of having two mash tubs was met by preparing the corn by steaming, rolling, etc., so that it was readily convertible in the mash-tun. This led to the introduction of corn flakes, first among which was "Cerealine." It cannot be denied that there are advantages in using these goods, which can be added directly in the mash-tun, especially in small breweries having only one mash-tun (see also "Mashing Operations").

In 1887 the United States Brewers' Association offered a prize for a pamphlet describing the known methods of raw cereal brewing, pointing out the best ones and giving reasons for recommending them, the rapid development of the matter having given rise to a need of throwing light on some of the less suitable methods. The task was performed satisfactorily by A. Weingaertner, who kept within the limits of the prescribed subject, which re

quired a criticism of existing methods, and only adding that where the taste and odor of the goods employed were not quite perfect an addition of some bone-black (1:1000) to the raw grain would do good service.

It having been discovered that the composition of wort did not always come up to what might be expected in practical work, A. Schwarz, about a year afterward, proposed to withhold part of the malt and add it to the total mash after the raw cereal wort had been run in, proper temperatures being observed. The proposition met with approval and proved successful.

Mention may here be made of an improvement in this process, which was made by R. Wahl. A greater degree of stability had come to be required, of late, in beer, and a slight haze was often found in beers made according to this method, or bottle beer became turbid readily. Wahl attributed this precipitate to the albuminoids of the malt last added, which could not be properly converted at the high temperatures at which they entered the mash. It is, therefore, advisable for bottle beers to dough-in all the malt at low temperatures, or to run off the liquid part of the mash at a low temperature and add it once more at a higher degree of heat.

Distilleries had long been employing steam pressure for the purpose of dissolving the starch of their raw material, potatoes and corn, and it was natural to introduce the same process into raw cereal brewing. Thausing referred to experiments in this line in 1882, mentioning the Macerator and the Hollefreund apparatus. Some experiments were also made in the United States, but no results obtained until, in 1887, L. Frisch carried these experiments out practically and by pursuing the idea made an unquestioned success of it. He was followed by Rach, whose process differed from that of Frisch, in that he combined with the dissolution of the raw cereal starch under steam pressure, a mashing method for obtaining worts with a relatively low percentage of sugar and high percentage of dextrin.

The extract obtained by Frisch from corn was much higher than this material had been known to yield before. It was subsequently found that by boiling the corn a longer time than had been recommended prior to this period (see Siebel, 1881, and *Weingaertner, 1887,* both of whom mention 30 minutes as th

maximum time of boiling) approximately the same yield could be obtained in the ordinary cooker.

PURE STARCH AS A MALT ADJUNCT.

Pure starch naturally was considered the most perfect raw adjunct for malt, and considerable quantities of wet or green starch were used in breweries, but with little success. Such attempts were frequently attended with deposits under the false bottom and consequent starch turbidity of wort and beer.

Recently, M. Henius succeeded in elaborating a method whereby the difficulties that prevented the use of pure starch in brewing are removed. Henius' method of treatment will be found in detail under "Treatment of Unmalted Cereals."

AMERICAN LAGER BEERS.

Materials.—In America pale malt is generally used for pale, as well as dark beers, for the latter an addition being made of caramel malt, black malt, roasted malt, roasted corn or sugar color. (See Brewing Materials.)

For pale beers, malt, together with unmalted cereals usually to the amount of one-third of the grist, but varying from 10 to 50 per cent, are used. The most popular material in an unmalted condition is prepared corn in the form of corn grits, or corn meal, while flakes are also largely employed, and have the advantage of direct addition to malt-mash, not necessitating any previous treatment whatsoever by the brewer. Corn flakes, rice and, lately, cornstarch share the favor of the brewer in the production of a high class bottle beer, and sugars, like anhydrous and glucose, may be used for kräusening purposes. Unmalted wheat is also employed locally.

As to the advantages of unmalted cereals, as compared with malt, it may be said that, aside from the point of view of economy, the character of the beer as produced by their aid meets with greater favor with the American public on account of lighter color, greater brilliancy and stability, and lighter body than all-malt beers.

As to the respective merits of the various unmalted cereals, cornstarch and other corn goods, like corn flakes, corn grits or meal can be used equally as well as rice, if the amount of corn *oil does not* exceed that of rice. Wheat has the advantage of a *er amount of* desirable albuminoids, but the disadvantage of a

larger amount of undesirable albuminoids also. Consequently, beers produced with the aid of wheat, instead of corn or rice, will show increased palate-fulness, but a decreased stability of the bottled goods.

The amount of materials to be used per barrel of beer depends upon the gravity or strength of the wort, and the yield of the material. The brewery yield will never be so high as the laboratory yield, but should approach it within 2 to 3 per cent. A good quality of malt should yield 64 to 65 per cent of extract, a good quality of corn grits, corn meal, 75 per cent, corn flakes and rice 78 per cent.

Malt Beers are brewed from 12 to 15 per cent Bllg., and require from 50 to 65 pounds of malt.

Pale lager beer should be brewed from 12 to 13 per cent Bllg., and require from 48 to 53 pounds, of which one-third may be unmalted cereals.

Pale bottled lager beers should be brewed 13 to 15 per cent Bllg., and require from 52 to 60 pounds of material, two-thirds of which may be malt and one-third unmalted cereals.

Temperance beers are brewed about 7 to 8 per cent Bllg.

Malt tonics are brewed about 15 to 18 per cent Bllg.

For details of the manufacture of bottle beers, temperance beers and tonics, see "Special Beers."

Water.—The amount of water to be employed in the production of one hundred barrels of wort is approximately 135 barrels. Some of the water employed is left in the grains (about 20 barrels), some is evaporated in boiling (about 10 barrels), some is evaporated on the surface cooler (about 5 barrels).

In the production of all-malt beers, one-half of the water employed in making a brew should be reserved for sparging. Where unmalted cereals, like corn and rice, are employed, three-fifths of the water may be reserved for this purpose.

MALT LAGER BEERS.

Strength of wort, 12 to 15 per cent, Balling.

Materials, 50 to 65 pounds of pale malt per barrel for pale malt beers. If beer is to have dark color use, along with the pale malt, a mixture of caramel and black malt to the amount of 6 to 12 pounds per barrel.

Take one barrel of water to 100 to 125 pounds of malt for doughing-in; *initial* temperature 100° F. (30° R.). Hold this

temperature 30 to 60 minutes, run up to 154° F. (54° R.) in 15 minutes with live steam and hot water, hold this temperature 15 minutes, run up to 163° F. (58° R.) in 15 minutes.

Live steam can be employed directly for heating the mash, if the water used for boiler feeding is of good or medium purity, i. e., if it does not impart to the steam any obnoxious substances. Care should also be taken in the selection of a proper boiler compound for the same reason.

Instead of heating with live steam the mash-tun may be provided with a steam jacket or coil.

Not more than one-half of the water to go into the mash should be used in doughing-in, leaving the other half for sparging.

Where live steam is not available and hot water must be used, the mash should ordinarily be started not lower than 133° F. (40° R.) in order to obtain a final temperature of 163° F. (58° R.) with enough water available for sparging.

Were the mash to be started below 133° F. (45° R.) too much water would be used for the mash liquor in raising the temperature of the mash, leaving correspondingly less for sparging.

An initial temperature in excess of 145° F. (50° R.) is not advisable in any case, as it interferes with the conversion of the albumen into peptones and amides.

Caramel and black malts are crushed and added to the malt mash when the temperature has reached 154° F. (54° R.).

PALE LAGER BEERS.

Strength of wort, 12 to 13 per cent, Balling.

Material, 50 to 55 pounds per barrel, of which about two-thirds should be pale malt and one-third may be unmalted cereals, like corn grits, corn meal, corn flakes, cornstarch or rice. Sugars like glucose may also be employed to the amount of about 25 per cent in place of unmalted cereals.

TREATMENT OF UNMALTED CEREALS.

The starch of raw cereals being more refractory than that of malt, requires longer boiling, together with malt or under high pressure. The common practice is to treat the raw goods in a separate vessel and run them in on the malt mash in the mash tub which has been previously started.

With *grits and meal* use: For 100 pounds of material in rice *tub, one barrel of* water; for 100 pounds of corn, 30 pounds of *malt. Boil grits* 75 minutes, meal 45 minutes.

With *rice* use: For 75 pounds of material in rice tub, one barrel of water; for 100 pounds of rice, 25 pounds of malt. Boil 30 minutes.

Start the malt mash as for a pure malt brew. Then start raw cereal mash in rice tank. Initial temperature, 100° F. (30° R.) in rice tank, hold this temperature 15 minutes, run up to 158° F. (56° R.) rapidly, hold this temperature 30 minutes, run rapidly to boiling point, boil for a time as indicated for the different materials, run mash into mash tub, so as to get a temperature of 154° F. (54° R.), when all is down. Hold this temperature in mash tub 15 minutes, raise to 163° F. (58° R.) with steam and hot water in 15 minutes.

After running down the raw cereal mash to the malt mash, a few barrels of water should always be forced in under the false bottom through the underlet, to clear the openings.

The more finely the goods are distributed and the longer they are cooked, the more completely will the starch be opened up. Corn or rice may yield 70 to 80 per cent of extract, malt, 64 to 68 per cent.

With *corn flakes* of good quality, that have been previously prepared in their manufacture so as to have the starch opened up, no cooking is necessary. Add these dry in mash tub, when temperature has reached 154° F (54° R.). Hold temperature 15 to 30 minutes (until saccharification) after addition, and run up to 163° F. (58° R.) in 15 minutes.

Corn starch should be treated in rice tank, as follows: For each 100 pounds of corn starch, use 30 pounds of malt. Dough-in with cold water, using one barrel for each 125 pounds of material; raise temperature to 160° F. (57° R.) in about 30 minutes, mash at this temperature for 30 minutes, go to 178° F. (65° R.) in 20 minutes, then rapidly to boiling, boil for five minutes and run down to malt mash.

Wheat and wheat malts are mashed together with the barley malt. Not more than 25 per cent should be employed, on account of the larger amount of undesirable proteids.

Sugars like glucose or grape-sugar are added in the kettle.

WAHL'S "LAUTER-MASH" METHOD.

In order to get worts richer in extract and with less alcohol than ordinary worts, use initial temperature of 100° F. (30° R.). Hold here 30 to 60 minutes, draw off the liquid portion—"lauter

[redacted]

mash"—reserve this at ordinary temperature, run the malt mash with the mash from the rice tank or with steam and hot water up to any point between 167° to 176° F. (60° to 64° R.), hold 15 minutes, and run in the "lauter-mash." The mash is now held at 167° F. (60° R.), and rapidly converted. The more alcohol and more extract is wanted, the higher is the temperature varied before addition of the "lauter-mash."

This "lauter-mash" may also be used in the rice tank instead of malt, especially to good effect when a high percentage of grits, meal or rice is employed in which case there is an insufficiency of malt husk in the mash-tun. The rice tank mash may be conducted as follows:

Run water of ordinary temperature into rice tank, one barrel to 110 pounds of material, turn on steam, run in material, raising temperature to 158° F. (56° R.), run in lauter-mash, holding temperature at 158° F. (56° R.) for 30 minutes, go slowly in 30 minutes to 176° F. (64° R.), then rapidly to boiling point, boil and continue as usual.

ANTON SCHWARZ'S AFTER-MASH METHOD.

Another method aiming to increase the percentage of unfermentable extract of the wort, is to reserve about one-third of the malt and add it to the mash after it has reached about 54° R., without necessitating the addition of any more water. This method can be recommended for unsteamed beers. It not only increases the percentage of unfermentable extract, but permits of the employment of more sparging water.

BONE-BLACK.

This is used in the mash at times to cure a mouldy odor of the goods.

If brewing materials—malt, corn, grits—have a mouldy or other off-smell, five pounds of bone-black, of the quality used in sugar refineries, run into the mash with the malt for every 1,000 pounds of material, will give a good result.

For raw cereal beers, add the bone-black while the raw cereal mash is running down into the malt mash.

RAW CEREAL MASH UNDER PRESSURE.

An increased yield will be obtained from raw cereals if they are cooked under pressure. There are two apparatus for this operation, in common use, the Hollefreund and the Henze.

The "Hollefreund" is an horizontal cooker, and was first operated according to Frisch's method, as follows:

Cold water is run into the cooker, then the corn goods. The temperature is raised to boiling point, the air is allowed to escape, the cooker is closed, the pressure is raised to 60 pounds 300° F. (120° R.). Hold here 15 minutes. Now blow off carefully, until 212° F. (80° R.) is reached, then connect with vacuum pump and reduce temperature to 158° F. (56° R.). Run in 15 per cent of malt, and after inversion, run up to 192° F. (71° R.) and run the raw cereal mash into mash tub.

The "Henze" apparatus is an upright cooker, and was first operated by Rach's method, as follows:

Water, corn and malt are run in, temperature is raised to boiling point, air is allowed to escape, then the cooker is closed, pressure raised to 30 pounds and the raw cereal mash forced into the mash tub. The temperature of the entire mash is usually raised to 181° F. (66° R.), then a "diastase solution," which was drawn at a lower temperature, is added, together with some cold water, to reduce the temperature to 172° F. (62° R.), where inversion takes place. Either method, however, can be modified according to circumstances.

Rach's method is based upon the principle of brewing beers with a low percentage of alcohol and high percentage of unfermentable extract. Both horizontal and vertical cookers can be used in connection with or without vacuum pump, and the same method of operation can be carried out in either. It is not advisable to raise the pressure higher than 30 pounds, as this is quite sufficient, unless darker worts are desirable. In conducting the malt mash and in running the cooker mash into the mash-tun, the temperatures in the mash-tun may be taken as given under "Pale Lager Beers" if a low percentage of alcohol in the beer is not desired.

Yield with pressure cooker—
From malt .... 64 per cent to 70 per cent
From corn or rice.............. 75 per cent to 80 per cent

Yield without pressure cooker—
From malt .... 64 per cent to 68 per cent
From corn or rice............ 70 per cent to 75 per cent

PALE EXPORT LAGER BEERS. (BOTTLED OR DRAUGHT.)

Export beers should be of a high grade. The amount of alcohol should be somewhat higher than in pale beers for the city trade on account of the greater requirements as to stability that the beers must meet, especially when not steamed.

Strength of wort, 13 to 15 per cent Balling.

Materials, 52 to 60 pounds per barrel, of which two-thirds may be malt and one-third fine quality of corn, rice, corn flakes, or cornstarch. Use low initial temperature, peptonize well by holding one hour and mash as usual. Details of export bottled and draught beer production, see under "Special American Beers," where will also be found temperance beers, tonics, common beer, steam beer, and others.

EXTRA PALE LAGER BEERS (BOTTLED OR DRAUGHT).

Strength of wort, 13 to 15 per cent Balling.

Materials, 50 to 56 pounds per barrel.

Use 50 per cent low dried malt, 30 per cent grits, rice or cornstarch, and 20 per cent anhydrous grape sugar or glucose;

Or use 50 per cent low dried malt, 30 per cent grits, rice, or cornstarch, and 20 per cent corn flakes.

The brewing water should be of medium hardness. If quite soft, darker color of wort and beer will result. If the water is too soft, it should be hardened by adding proper amounts of sulphate of lime. Alkali waters should be treated by adding chloride of calcium or plaster of Paris.

Start mash at 122° F. (40° R.) instead of 100° F. (30° R.), hold for about 15 minutes, and then proceed as usual.

THE MASH AT REST.

When the end temperature is reached, a sample of the mash should not show any starch by the iodine test. If it does, we should continue to run the machine until all starch has disappeared, or, if we have reason to assume that this would require too long a time, we should cool the mash to 158° F. (56° R.) with water—in case of malt poor in diastase—and add some more crushed malt. The last few degrees should be obtained by running hot water through the underlet or "pfaff."

The stirrer is now stopped, or, in the mashing machines of modern construction, lifted out of the mash. Shortly after *the stirring has stopped,* the surface of the mash should appear

grained or mottled. The taps are now opened, one after the other, the wort is allowed to rush out for a few seconds, and the taps are again closed. This is done to remove underdough. Let the malt mash rest 30 minutes and the raw cereal mash 45 minutes. If allowed to remain standing too long the grains will settle too firmly.

RUNNING OFF THE WORT.

Open the taps wide, one by one, for a few seconds, and close them again; the recoil of the liquor will rinse out more underdough. Then open the taps gradually until a proper flow of wort is obtained. Pump the wort back into the mash tub as long as it runs turbid, which usually lasts 8-15 minutes. As soon as the surface of the grains has run dry, remove the upperdough, or stir it up with crutch or machine to prevent channels being formed in the goods, which would prevent the sparging liquor percolating uniformly through the grains.

The wort should flow quite bright. If it remains hazy after all suspended matter has disappeared, there are undesirable albuminoids present, caused either by imperfect malt or faulty mashing.

SPARGING.

This process consists in sprinkling hot water over the grains to wash out as much as possible of the valuable constituents remaining in them. The amount of sparging water should be considered when starting the mash, with reference to the total amount of wort desired.

When so much wort has been drawn off that the grains are barely covered by the liquid, sparging should begin. Sparge four to five times, using for each 100 barrels of sparging water:

For first sparging	30 bbls.
For second sparging	25 bbls.
For third sparging	20 bbls.
For fourth sparging	15 bbls.
For fifth sparging	10 bbls.

Or, the sparging water can be sprinkled on continually as fast as the wort runs off, keeping the grains covered about one inch with water. The temperature of the sparging water should be 167-172° F. (60-62° R.). Higher temperature may lead to starchy turbidity, lower temperature to souring. The spargings should be tested from time to time for starch. The first wort may be absolutely

free from starch while the spargings may show considerable amounts of starch, generally due to the employment of high sparging heats. If the first wort runs off too slowly, let it run off entirely, then start machine, mixing the grains thoroughly while the first sparging water is forced in through the underlet.

The first wort should have a gravity of 18 to 20 per cent Balling, varying with the amount of water used for malt and cereal mashes.

Enough sparging water having been added and the wort having run off almost entirely, the last run will be turbid, but should have no greater density than .1 per cent by the saccharometer.

The loss due to incomplete washing out of the grains is approximately equal in per cent to the percentage that the water pressed from the grains shows. In order to compute the loss from this source, take a sample of grains from the grains-box, press it, and find the amount of extract in the water by means of a saccharometer. If this were found to be 1 per cent, then the amount of loss would be 1 per cent of the weight of the material employed, since the amount of water in the grains is approximately equal to the weight of the grist. If, f. i., 8,000 pounds of malt and 4,000 pounds of corn were used for a brewing, and the weight of the water pressed from the grains was 2 per cent, then the loss would be 12,000 $\times$ 2 per cent $=$ 240 pounds, or about seven barrels of wort of 13 per cent.

SLOW FLOW OF WORT.

If the wort flows too slowly it is generally an indication that the goods have not been completely opened up, but it may also be due to one or more of the following causes:

1.—EXCESS OF UNDERDOUGH.

By underdough we mean those substances which gather between the false bottom and the real bottom of the mash-tun. Were this space to fill up completely, the wort and spargings could not run off at all. Where this space is filled up partly, the grains lying above the clogged section will not drain properly.

The underdough is mainly composed of starch.

The following conditions promote the formation of underdough:

a.—Crushing the malt too finely. The malt should not be *ground fine, but* each kernel should be simply crushed. The

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less malt flour finds its way readily through openings of the false bottom, the better.

b.—Running mash machine too long, especially at low temperature. The longer the mash machine is run, f. i., at 100-122° F. (30-40° R.), at which temperature the starch remains practically unchanged, the more of this starch will work its way under the false bottom. If the mash is to be held at a low temperature for some time, the machine should be stopped.

c.—If little or no water is run under the underlet while the mash machine is in operation, more solid particles will find their way under the false bottom, the upward current of water checking, in part, the downward motion due to gravitation.

d.—If the holes in the false bottom are large, underdough will be formed more readily.

e.—If the space is high below the false bottom, underdough will form more readily. (See also Brewing Outfit.)

2.—EXCESS OF UPPERDOUGH.

By upperdough we mean the layer of finely divided light particles uppermost in the grains. This layer is, in the main, composed of particles of cellulose and albumen, and the more of it forms,

a.—The finer the malt is crushed,

b.—If the mash machine is run too long, resulting in more particles being scraped off the husks, etc.

c.—If a large proportion of unmalted cereals is used.

This upperdough should always be removed by chopping and mixing it into the body of the grains before sparging.

3.—GRAINS SETTLING TOO COMPACTLY.

This may be due to:

a.—Letting the mash rest too long before tapping; 30 to 45 minutes should be sufficient.

b.—Draining the first wort, or spargings, too rapidly, in which case the liquor not being able to percolate through the grains as fast as it runs from under the false bottom, has the effect of compressing the grains, in proportion to the height of the liquid column.

c.—Running too much sparging water on the grains, this water acting as so much weight,

d.—If malt is flinty,

e.—If the mash-tun is too high in comparison to diameter; the mash in the tun should be about 36 inches high, the grains after draining about 18 inches.

4.—SCARCITY OF FILTERING MATERIAL.

a.—When using large amount of unmalted cereals,

b.—When using malt with thin husk,

c.—When using much malt in rice kettle.

d.—If the diameter of the mash-tun is too large compared with its height, in which case the layer of filtering material (grains) will be too low.

5.—GRAINS STOPPED UP.

If the body of the grains becomes stopped up by unconverted starch in a semi-paste form, or by undesirable proteids.

BOILING THE WORT.

PRINCIPLES OF BOILING.

The wort obtained by mashing is boiled for a certain period for the purpose of eliminating or rendering harmless certain undesirable constituents, and introducing other new bodies by extraction from the hops. These changes taking place during heating and boiling are the following:

1.—*Destruction of the diastase above* 178° F. (65° R.).

2.—*Precipitation of the proteids,* which is the more complete;

a.—If mash is well peptonized, that is, if the mash was held sufficiently long at lower temperature, in which case there is a larger amount of precipitation, and this precipitation is more flocculent than when employing high initial mashing temperatures.

b.—If the wort is boiled the proper length of time. The proteids are not precipitated at once when boiling temperature is reached. They continue to be precipitated on extended boiling. It seems, however, that certain forms of albuminoids, probably the albumoses, are changed to proteids of a type that is not readily precipitated on boiling, but remains in the wort and gives rise to proteid turbidity in the wort or beer on cooling. At any rate, it has been observed that prolonged boiling results in bottled beers of decreased stability when steamed.

c.—If boiling temperature is below 212°, less proteid matter will be precipitated than at 212° boiling point. On this account it is difficult to brew beers of good keeping quality in breweries *located at* high altitudes (in the Rocky Mountains, f. i.). *The copper kettles* in such breweries should be so constructed

as to admit of boiling under a pressure of about five to ten pounds.

d.—If the wort is aërated during boiling the proteids seem to be precipitated more effectually. The door of the copper should, therefore, be kept open during boiling.

e.—The tannic acid of the hops aids in precipitating proteids; the more hops employed, the more proteids are eliminated.

f.—If the hops are added after most of the proteids are precipitated, that is, after about an hour's boiling, an additional quantity of proteids will be precipitated. The hops should not, therefore, be added too soon.

3.—*Evaporation of water.*

4.—*Deepening of the color* by concentration of the wort and formation of caramel, by means of the heat acting on the sugars.

5.—*Extraction of hop oil and hop resin.*

6.—*Destruction of bacteria.*

BOILING OPERATIONS.

In the United States the wort is always heated by steam, open fire kettles having gone quite out of use. Steam is turned on when the wort flowing from the mash tub covers the heating surface in the copper, and the temperature kept at about 190° F. (70° R.) until all the wort, including spargings, has run in. Unless very pale beer is desired, the brewer may bring the wort to a boil while it is flowing in. During the boiling period the wort should be kept in a state of vigorous ebullition.

An addition of hops of about 10 pounds per 100 barrels is given as soon as the wort comes to a boil, which has the effect of decreasing the danger of wort boiling over.

"BREAK" OF WORT.

While the wort is heated the undesirable albuminoids are partly precipitated and unite into lumps. The fluid between these floating lumps should, in time, become clear and transparent. This is the "breaking" of the wort, and it should be well "broken" before any hops are added.

BOTTLE BEER AND EXTRA PALE.

For bottle beer and extra pale beer, hold the temperature of the wort at 190° F. (70° R.) until the kettle is full. Boil for one hour, at the expiration of which time the wort should show a good first break. Then add ⅔ of the hops (fair quality), boil

40 minutes, when the wort should show a good second break. Add 2/5 of hops of a better quality, boil 20 minutes. Add 1/5 hops of the finest quality, and run out immediately. If the first or second break does not set in within the given time, do not use the beer for bottling.

For ordinary beers, boil until the wort is broken, and add first 2/5 of hops; otherwise proceed the same as for bottle beer.

HOPPING THE WORT.

The active agents extracted from the hops by boiling are the "resins," "oil," and "tannin."

The hop-resins impart the bitter taste, tend to preserve the beer, and protect the yeast.

The hop-oil gives the aroma of hops.

The tannin contributes to the precipitation of the albuminoids from the boiling wort.

An extension of the boiling period means the extraction of more hop-resin and tannin and the volatilization of more essential oils, causing a loss of aroma. The door of the copper is kept open while the wort is boiling, in order to admit air, which promotes the elimination of albuminoids.

The hops are added in portions, in order to secure both the desired bitter and aroma. The allowance of hops should be increased with a greater concentration of the wort. The inferior quality of hops should be added in the first portion.

The quantity of hops that ought to be used per 100 barrels of wort of 13 per cent B. is about 100 pounds; for lighter beers, less; for stronger ones, and for bottled beers, more.

HOP PREPARATIONS.

There are certain preparations made from hops which may be used to good advantage instead of the whole cone. Such preparations are hop extract and lupulin.

A hop extract is produced by extraction in naphtha, which is the dissolving agent usually employed. This naphtha is afterward driven off by evaporation.

Lupulin from good hops, and unadulterated, is quite unobjectionable, but care should here be taken, as the high price of the product is a temptation to adulterate it, and it occurs in the market mixed with sand, tannin, brickdust, etc., or it is taken from old hops.

Only 25 per cent of the hops should be replaced by these ducts, employing one pound of hop extract for 12 pounds

of hops of the first portion of two-fifths, or one pound of lupulin for 12 pounds of the second portion of two-fifths, or the third portion of one-fifth. The can containing the hop extract is punctured, tied to a chain and hung into the boiling wort near the bottom. Under these circumstances the extract will be dissolved more readily.

AIDS FOR ELIMINATING ALBUMINOIDS.

"Irish moss" is often added in the kettle. It should be washed with cold water and 2.5 pounds taken for 100 barrels of wort, adding the same ten minutes before running out. Long boiling weakens the effect of the moss.

The effect of the moss is due to a glue-like substance, which acts in a similar manner to isinglass. It operates after the wort has cooled, by coagulating, and enveloping the floating albuminoids, causing them to ball up more readily and seek elimination, either by rising to the surface or settling.

Fifty pounds of "common table salt" added for 100 barrels of wort is recommended where the brewing water contains no salt. It not only aids the "breaking" of the wort, but also improves the taste of the beer. It should be added about half an hour before running off the wort from the copper.

COOLING.

From the copper, the wort runs into the hop jack, where it is allowed to stand for a period, to permit the hops and albuminoids to settle.

The wort should not be allowed to rest longer than 15 minutes, as a dark color or rank, bitter taste may result if wort is left in contact with hops too long. Where the wort cannot be taken care of by the coolers within a reasonable time, it would be advisable to provide a suitable storage tank for the hot wort, or to place the false bottom of the hop-jack higher up, or else provide the kettle with a hop strainer.

The hops should be sparged with about five barrels of hot water per 100 pounds of hops. As the hops form but a thin layer in the hop-jack, they could be profitably taken out, placed in a separate strainer with smaller diameter—a hop press with a metal shell instead of basket would answer—where sparging would be more effective. (See Brewery Outfit.)

The hops should not be pressed, as is often done, as substances are thereby embodied in the wort that tend to impart a *rank, bitter* after-taste to the beer.

THE WORT ON THE SURFACE COOLER.

The wort is next run or pumped to the surface cooler for the purpose of preliminary cooling.

The wort should be cooled to 145° F. (50° R.), and not lower, on the surface cooler, and receive proper aëration during cooling, avoiding all sources of contamination in the meantime. Aëration of the wort during cooling has the effect of further precipitating undesirable albuminoids. Besides, the wort absorbs air, which is utilized by the yeast later on. Most of the microbes that reach the wort below 145° F. (50° R.) will remain alive, the most common ones being butyric and lactic acid ferments and wild yeasts.

The wort cools the more rapidly:

1. The lower the temperature of the air;
2. The better the aëration; Theurer's apparatus dispenses with the surface cooler altogether. The wort is pumped into a vat and thence runs straight over the Baudelot cooler, which is supplied with filtered air. Aëration is complete, and the danger of infection minimized;
3. The more the wort is agitated, for which purpose stirrers may be employed;
4. The larger the surface of the wort compared with its depth;
5. When atomized; for this purpose the wort may be sprayed on to the surface cooler, the wort thus coming in contact with a large quantity of air, which increases aëration and accelerates cooling. The danger of infection, however, must not be ignored. If a spraying system of cooling and aërating be adopted, the air that has access to the surface cooler should be filtered;
6. When the sky is clear, more rapidly than when cloudy;
7. When the surface cooler is constructed of metal, more rapidly than when made of wood.

If the wort looks foxy on the surface cooler, it contains in suspension bodies that will not settle readily.

After the preliminary cooling the wort is sent over the *Baudelot cooler*, where it should be cooled down to 48° F. (7° R.),

which is sufficiently low. Formerly it was a general rule, however, to cool the wort to as low a temperature as 42° F. (4.5° R.). At this temperature in the settling tank it should show a good, cold "break," and a sample should filter clear at the temperature of the fermenting cellar. If it does not, the causes may be as follows:

CAUSES OF UNSATISFACTORY "BREAK" OF WORT.

1. Starchy turbidity from incomplete inversion of the starch.
2. Proteid turbidity from incomplete inversion of the albuminoids or incomplete precipitation of the proteids.
3. Bacteria or yeast turbidity from infection.

A good cold break is an indication of a perfect wort.

LOSS IN VOLUME IN PRELIMINARY COOLING OF WORT.

A certain loss in volume will occur on the passage of the wort from kettle to settling tank, due to the following elements:

1. Contraction in cooling	4.5 p. c.
2. Evaporation of water	4.5—5.0 p. c.
3. Adhesion of liquid to surfaces of kettle, hop-jack, cooler, etc.	½ p. c.
4. Wort adhering to hops in hop-jack when not pressed or sparged two barrels and one-half per 100 pounds of hops or approximately	2.5 p. c.
Total loss when hops are not sparged or pressed, approximately	12½ p. c.
5. By sparging with five barrels of water per 100 pounds of hops, the total loss will be reduced to about	7½ p. c.

Thus, 92½ barrels will reach the settling tank out of every 100 barrels leaving the kettle, if five barrels of water are employed for sparging 100 pounds of hops. By contraction in cooling and by evaporation no valuable substances are lost, excepting hop-oil.

(For German lager beers, ale, stout, weiss beer, common beer, see end of this chapter.)

INFLUENCE OF DIFFERENT MATERIALS AND MASHING METHODS ON THE COMPOSITION OF WORT.

The table on the next two pages shows the influence of different materials and mashing methods on the composition of wort which in a great measure determine the character of the beer. It is very interesting to note that from the same malt, worts wer-

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INFLUENCE OF DIFFERENT MATERIALS AND MASHING METHODS ON THE COMPOSITION OF WORT. BY M. HENIUS. THE BREWS WERE MADE IN THE EXPERIMENT BREWERY OF THE AMERICAN BREWING ACADEMY OF CHICAGO.

o.	Material.	Temperature of Water, F.	R.	Mashing Method.
1.	All malt.	178°	65°	Mashed between 165°-169° F. 20 minutes. (59°- 61° R.)
2.	All malt.	145°	50°	Mashed at 140° F. (48° R.) 2 hours. In one-half hour to 158° F. (56° R.)
3.	All malt.	106°	33°	Mashed at 100° F. (30° R.) 15 minutes. Rest mash at 100° F. (30° R.) 1 hour. With steam to 122° F. (40° R.) in 10 minutes. With steam to 153° F. (54° R.) in 20 minutes. Mash at 153° F. (54° R.) 10 minutes. With water to 165° F° (59° R.) in 10 minutes.
4.	65% malt. 35% grits.	106°	33°	Mashed at 100° F. (30° R.) 15 minutes. Rest mash at 100° F. (30° R.) 1 hour. With grits mash to 153° F. (54° R.) in 20 minutes. Mash at 153° F. (54° R.) 10 minutes. With steam to 165° F. (59° R.) in 20 minutes.
5.	65% malt. 35% grits.	106°	33°	Mashed at 100° F. (30° R.) 15 minutes. Rest mash at 100° F. (30° R.) 1 hour. Draw Lauter-mash. With steam to 140° F. (48° R.) in 20 minutes. With grits mash to 176° F. (64° R.) in 6 minutes. Add Lauter-mash, reducing temp. to 165° F. (59° R)
6.	60% malt. 40% rice.	127°	42°	Mashed at 122° F. (40° R.) 10 minutes. Rest mash at 122° F. (40° R.) ½ hour. With rice mash to 156° F. (55° R.) in 8 minutes. Mash at 156° F. (55° R.) 15 minutes. With steam to 165° F. (59° R.) in 15 minutes.
7.	65% malt. 25% flakes.	127°	42°	Mashed at 122° F. (40° R.) 10 minutes. Rest mash at 122° F. (40° R.) 30 minutes. With steam to 158° F. (56° R.) in 15 minutes. Add flakes at 158° F. (56° R.) in 15 minutes. Mash at 158° F. (56° R.) 15 minutes. With steam to 165° F. (59° R.) in 10 minutes.
8.	75% malt. 25% wheat malt.	115°	37°	Mashed at 111° F. (35° R.) 15 minutes. Rest mash at 111° F. (35° R. 45 minutes. With steam to 149° F. 52° R.) in 10 minutes Mash at 149° F. (52° R.) 10 minutes. With steam to 165° F. (59° R.) in 20 minutes.

INFLUENCE OF DIFFERENT MATERIALS AND MASHING METHODS ON THE COMPOSITION OF WORT. BY M HENIUS. THE BREWS WERE MADE IN THE EXPERIMENT BREWERY OF THE AMERICAN BREWING ACADEMY OF CHICAGO.—(Continued.)

Yield lb. Extract in 100 lb. Material.	Original Gravity Per cent Balling.	Reducing Sugars. (Rohmaltose.)	Per cent Sugar (reducing) in Extract	Ratio of Sugar to Non-Sugar.	Albuminoids in 100 parts wort.	Per Cent Albuminoids in Extract.	Remarks.
56	11.8	6	51	100:97	0.6	5.1	Wort runs turbid, poor break in kettle and after cooling.
61	12.7	10.3	81	100:23	0.8	6.3	Wort runs fair; fair break in kettle and after cooling.
63	13.2	9.5	72	100:40	0.95	7.2	Wort runs clear. good break in kettle and after cooling.
67	12.5	9.6	77	100:30	0.56	4.4	Wort runs clear; good break in kettle and after cooling.
67.3	12.6	7.4	50	100:70	0.53	4.2	Wort runs clear. Good break in kettle and after cooling.
67.8	13.5	9.3	69	100:45	0.52	3.9	Wort runs clear; good break in kettle and after cooling.
67.3	14.1	9.4	66.7	100:50	0.67	4.3	Wort runs clear; good break in kettle and after cooling.
66.4	13.1	9.5	73	100:38	0.9	6.9	Wort runs clear; good break in kettle: fair after cooling.

obtained in which the amount of sugar varied from 51 to 81 per cent of the weight of the extract, while the albuminoids varied from 5.1 to 7.2 per cent. High initial temperatures yielded worts with a low percentage of sugar and low percentage of albuminoids. The malt mash held at 30° R. one hour was shown to give the best results regarding amount of albuminoids. Whenever unmalted cereals were employed the amount of albuminoids was reduced proportionally with their amount. Wheat malt yielded an equal amount of albuminoids as barley malt. The worts from the high initial temperature mash No. 1 and from No. 2 where the machine was run abnormally long, ran turbid or fair from the grains and did not break well in the kettle and after cooling, and the beer from No. 1 did not clarify. The wheat malt wort acted in the same way, only it ran clearer from the grains. All other worts ran brilliant from the grains, broke well in the kettle and after cooling, and the beers clarified properly.

Mashes 1 and 2 were made with a view to determine the extremes of dextrin and sugar percentages in the extract of the wort, and have no practical significance. Mashes 4 and 5, which were produced with the same properties and qualities of malt and grits, show that the percentages of sugar can be materially lowered by raising the temperature more rapidly from the initial to the final temperature, especially when Wahl's Lauter-mash is employed, as is the case in Mash 5. Mash 7 shows the reduction of sugar and a corresponding increase of dextrin by the addition of corn-flakes at a higher temperature as compared with Mash. 4.

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FERMENTING CELLAR OPERATIONS.

METHODS OF FERMENTATION.

With reference to the character of the beer to be produced, as far as it is determined by the process of fermentation, three methods of conducting fermentation are distinguished:

1. Top fermentation, for ale, stout, porter, weissbeer.
2. Bottom fermentation, for lager beer and American steam beer.
3. Spontaneous fermentation, for Belgian beers (Lambic, Faro).

Bottom fermentation proceeds at low temperature, viz., 42-51° F. (4.5-8.5° R.); top fermentation at higher stages, as 57-73° F. (11-18° R.). In bottom fermentation, the temperature during the process rises 7 to 11 degrees F. (3-5° R.); in top fermentation, 11-16 degrees F. (5-7° R.).

The designations of the two types of fermentation are derived from the fact that in bottom fermentation the yeast for the most part settles on the bottom, whereas, in top fermentation, it rises to the surface.

Bottom fermentation takes 8-16 days; top fermentation but a few days.

STAGES OF FERMENTATION.

Fermentation in the brewery proceeds in two distinct stages:

1. "Principal," "primary," or "main fermentation," consisting in the splitting of maltose at relatively higher temperature, for bottom fermentation, 42° to 51° F. (4.5° to 8.5° R.); for top fermentation, 57° to 73° F. (11° to 18° R.).
2. "Secondary," or "after-fermentation," consisting in the splitting of the malto-dextrin at lower temperatures, in bottom fermentation by culture yeast at 34-37° F. (1-2° R.); in top fermentation by culture or wild yeast about 55° F. (10° R.).

AVERAGE PROGRESS OF PRINCIPAL FERMENTATION.

System of Fermentation.	Yeast.	Temperature.	Period.	Result.
Bottom fermentation ..	Bottom	42—51° F 4.5—8.5° R.	8—16 days.	few foreign ferments, little lactic acid.
Top fermentation	Top.	57—73° F. 11—18° R.	3—5 days.	more foreign ferments, more lactic acid.
Spontaneous fermentation.	Wild yeast and bacteria.	57—66° F. 11—15° R.	30—40 days.	many foreign ferments, much lactic acid.

BOTTOM FERMENTATION.

PITCHING WITH YEAST.

Fermentation is induced in the wort by adding yeast, which operation is called "pitching."

The wort runs from the pipe cooler into a collecting vat or straight into the fermenter, where fermentation is started. During pitching the wort should be well roused repeatedly, so as to secure a uniform distribution of the yeast and an intimate mixture of yeast and wort. There are different ways of pitching.

REFRESHING AND DEVELOPING THE YEAST.

Before the yeast is added to the bulk of the wort it is mixed with about an equal quantity of either finished wort or boiled first wort of 55-68° F. (10-15° R.), well aërated, and added either at once or after the yeast has developed, that is, after the mixture has come into Kräusen. The mixing and aërating may be done in special appliances, stirring the wort and yeast vigorously while at the same time air, preferably filtered air, may be blown into the mixture. Where the amount of yeast to be handled is not very large it may be effectively roused and aërated by pouring the mixture of wort and yeast repeatedly from one bucket into another, letting it fall through the air as high as a man can lift it.

When the refreshed yeast is allowed to come into Kräusen, and is then added to a large quantity of wort, the sudden drop in temperature may check the growth of the yeast, which has by this time become vigorous. It is therefore a better plan to let the wort as it cools run into the refreshed and developed yeast, which may for this purpose be placed into the settling tank or pan of the Baudelot cooler.

While running the wort into the settling tank which contains

the yeast, the wort should be roused either with crutches or it may be roused and aërated at the same time by blowing in filtered air.

DOUBLING.

The wort is pitched as usual with the refreshed and developed yeast. When the beer in the vat has come into Kräusen it is divided into two parts, and each vat is filled up again with wort; when this is in Kräusen, it may be again divided, and the vats filled up. Then the fermentation is allowed to proceed as usual, but the operation may be repeated a number of times more with good results. This method may be well employed when the yeast is changed and it is desired quickly to propagate a new crop of yeast from a small quantity introduced; 50 to 60 pounds of yeast will give a new crop of 150 to 200 pounds of new yeast from every 50-barrel vat.

AMOUNT OF YEAST FOR PITCHING.

The amount of yeast per barrel required to secure a normal fermentation is governed by the density of the wort, the pitching temperature, the condition and properties of the yeast, and the treatment of the same. The stronger the yeast, the weaker the beer is brewed in, the better the aëration and the higher the pitching temperature (within reasonable limits), the smaller will be the quantity of yeast necessary for pitching; ordinarily 1¼ pounds per barrel will be found sufficient where the original gravity of the wort is 13 per cent B., the pitching temperature 42° F. (4.5° R.), and the yeast thick and strong. If boiling fermentation sets in, more should be used.

Where the yeast is added dry without refreshing and developing, more yeast is required. The smallest amount is needed where the wort is run in on the refreshed yeast.

FERMENTATION PHENOMENA.

Within 15-24 hours, according to the pitching temperature, little white bubbles appear around the sides of the vessel. The wort at this time is covered with a head of a thick, lumpy consistency, composed largely of albuminoid matter, coagulated during the boiling period. Upon blowing aside this head, a fine white froth will be observed underneath, indicating that fermentation is setting in. The head of impurities being skimmed off, the whole surface is found to become quickly covered with

a fine white froth ("whitening over"), rather higher around the rim than in the middle. This shows that fermentation has become active, and takes place 18-30 hours after pitching.

KRAEUSEN.

The head of froth begins to move from the sides of the vessel to the middle, and assumes a frizzled appearance, small cockle-shaped mounds beginning to rise all over the surface. This is the stage of "Kräusen," answering to what the English brewer **call the "cauliflower" stage. At the expiration of 20 to 40 hours after pitching, the surface should be curly and pure white. ("Young Kräusen"). From the time the froth head begins to move toward the middle, fermentation becomes more active, the head rising higher all the time ("High Kräusen"). At the** same time the temperature rises, slowly at first, more rapidly as the activity of fermentation increases, while the saccharometer falls with increasing rapidity, the drop amounting to one-fourth to one-half of one per cent. a day in the early part, and reaching one to one and one-half toward the high Kräusen stage. The curly head of froth turns a darker color while rising in height. The dark secretions commonly collect at one point and form a cap.

The high Kräusen stage is reached 70 to 80 hours after pitching and is maintained for a period of 48-72 hours, varying according to different influences. During this time the beer is kept at a certain low temperature, 48° to 50° F. (7° to 8° R.), by means of attemperators, and when the head begins to collapse is cooled slowly to 39° F. (3° R.). The saccharometer falls more slowly as the end of the principal fermentation draws near. When the end is reached, the fall of the saccharometer should be $\frac{1}{10}$ to $\frac{1}{20}$ per cent in 24 hours.

COLOR AND "BREAK"

The color of the beer begins to deepen from the time of the Kräusen collapsing, and from a foxy appearance it gradually passes into a deep black, about 8 to 16 days after pitching. At that period, if a sample is taken in a sample glass, the yeast particles suspended in it should be visible to the naked eye. The yeast should bunch together, the beer should "break" well. In a *sample* glass the impurities should settle in 2 to 3 hours in a warm *room, and in* 24 hours in the fermenting room, leaving the

beer perfectly clear. These conditions existing, the principal fermentation is completed.

THE YEAST CROP.

When the beer is ripe for tanking (racking on Ruh), the beer should be drawn or pumped from the fermenting vat, avoiding all agitation. as the yeast has a tendency to rise by the escape of carbonic acid gas under the yeast.

The quantity and soundness of the yeast crop are largely influenced by operations during the progress of fermentation. In the beginning the matter in suspension in the wort, composed mainly of proteids, will partly settle and partly gather at the surface in the fermenting tub. In order to obtain the yeast as free as possible from this suspended matter, hop-resin and other substances like hop-resin that appear in the Kräusen:

1. Skim off the dark head after the appearance of Kräusen, or run the beer into another vat as soon as in Kräusen.
2. Remove the dark particles of hop-resin from the Kräusen while the latter are falling back.
3. Skim off the cover before racking on storage ("Ruh").

The bulk of the yeast will be found settled on the bottom. The top, which is darker from admixtures of hop-resin, is apt to contain more light yeast, and small cell types, like wild yeast, if present in the beer at all, are found in greater quantities in the top layer. This dark layer should be skimmed off. The middle layer will be found to be lightest in color, and this part only should be preserved for future fermentations, leaving the bottom stratum, which again has a deeper color, and, having been first deposited, contains larger quantities of old, dead, and weak yeast cells, to go among the refuse.

The middle layer which is conveyed to a yeast tub, may be at once refreshed and developed for pitching or left standing without watering for a few days if properly kept cool by "swimmers," or attemperator pipes, not by ice directly, since ice may contain impurities. The yeast may also be watered, which is preferably done the day before using. Next morning the surface water with the yeast particles floating on it is drained off, and the yeast refreshed and developed as for a new fermentation.

The new yeast crop should be most carefully examined before being used again, and if found in any way unsound or contaminated, *should be* treated as directed under the respective *heads.*

FERMENTATION PHENOMENA EXPLAINED.

The fermentation phenomena may be explained as follows: As soon as the yeast is stirred into the wort it begins to split up the sugar into alcohol and carbonic acid, thereby developing heat, in consequence of which the temperature of the fermenting liquid rises, and the indication of the saccharometer becomes lower as the sugar is decomposed. The carbonic acid escapes, with the exception of about ⅕ per cent, which remains in the beer, part of the escaping gas raising the head of Kräusen. This escaping gas carries to the surface all the flocculent particles in suspension, like the coagulated albuminoids, giving rise, in the first stages of fermentation, to the thick, dark cover of scum. The hop-resin, which is held in solution chiefly by the sugar, becomes less soluble as the sugar decreases, and is carried, together with coagulated albumen, to the surface of the beer, where it discolors the Kräusen, or settles on the bottom, discoloring the yeast. The yeast multiplies during fermentation, is kept suspended by the escaping carbonic acid gas, and thus gives the beer a somewhat reddish appearance. The activity of the yeast increases up to the high Kräusen period, then gradually settles, and as fermentation draws to a close the beer appears darker in the vat. When the head collapses, there is comparatively little sugar left in the wort. Hence, the saccharometer falls with increasing rapidity up to the collapse of the head, and the temperature rises, whereas, after that time, the saccharometer falls more slowly, and the temperature decreases, owing to the atmosphere of the fermenting room being about 41° F. (4° R.) and cooling the liquid more rapidly than the diminishing activity of the yeast serves to heat it, even without the use of attemperators.

The higher the temperature, and the larger the quantity of yeast in the beer, the quicker will the sugar ferment, the quicker will the temperature rise, the quicker will the saccharometer fall, the quicker carbonic acid will develop, the higher will the Kräusen rise.

The fall of the saccharometer indication, according to Balling, is called "apparent attenuation," and the percentage of this fall, the "apparent degree of attenuation." The indication of the saccharometer itself at the end of the fermentation period is called the "apparent extract of beer." Taken together with

the original gravity of the wort, the apparent attenuation enables the calculation of the percentage of alcohol, from which, in turn, is determined the real attenuation, the "real degree of attenuation," and the Balling of beer. (See "Figuring in the Brewery.")

The consistency of the Kräusen head is due largely to the viscousness of the albuminoids by which the high volutes of foam are held together, to collapse after the generation of carbonic acid has fallen below the amount necessary to support the foam.

The yeast does not ferment all the sugar in the wort, but leaves an average of 1.5 per cent after the principal fermentation, of which about one-half per cent is maltose and one per cent malto-dextrin. (See "Bottom Yeast.")

AN AVERAGE FERMENTATION RECORD.

As indicated by thermometer in degrees F. and R.	42 4½	42¾ 4¾	43¼ 5¼	 6	48 7	51 8½	51 8½	51 8½	49 7½	46 6½	44 5½	42 4½	40 3½	39 3
By saccharometer in per cent........	13	$12\frac{6}{10}$	12	11¼	10¼	9	7¾	6½	5¾	5¼	5	$4\frac{8}{10}$	$4\frac{7}{10}$	$4\frac{6}{10}$
Period of fermentation in days after pitching	0	1	2	3	4	5	6	7	8	9	10	11	12	13

HIGHER PITCHING TEMPERATURES.

The wort, upon reaching the starting tub, always contains foreign germs which it took up on the surface and Baudelot coolers. Before fermentation starts, these foreign germs will multiply with comparative rapidity, and after fermentation has started, are suppressed the more effectively, the more quickly fermentation reaches the high Kräusen stage, at which the fermenting action of the yeast is at its height, as is the temperature of the fermenting liquid.

The old practice is to cool the wort to 42° F. (4.5° R.) and to allow hours to pass before pitching, sometimes waiting over night. This is not in accordance with scientific principles, and, consequently, Wahl, on the occasion of a convention of the United States Brewmasters' Association, held at Baltimore, proposed the following treatment for use in American breweries:

Refresh and develop the yeast with first wort of 59° F. (12° R.) and put in the starting tub, timing this preparation so that the mass is just beginning to ferment at the moment when the first wort reaches the starting tub from the Baudelot cooler. The wort should run on the yeast, instead of the yeast being put into the wort. The wort is cooled down to 49° F. (7.5° R.) instead of 40-42° F. (3.5-4.5° R.).

When in Kräusen—which will be in 20 to 24 hours instead of 40 to 45 as by the old practice—pump the wort into another vat or distribute among the fermenters. The temperature will have reached 51° F. (8.5° R.) by this time. Keep it at this height by means of "swimmers," or attemperators until the Kräusen have fallen down sufficiently, and cool in about three days down to 39° F. (3° R.), working so that the decrease of the saccharometer in the last 24 hours will not exceed 0.1 per cent.

The advantages of this practice are many:

1. The wort need not be cooled down so low, that is, refrigeration is saved.
2. The wort is ready for pitching sooner.
3. Fermentation sets in sooner.
4. Fermentation is finished 2 to 4 days earlier.
5. The development of the yeast is more vigorous.
6. The yeast remains purer.
7. Less Kräusen are needed, their temperature being higher; or, equal amounts of Kräusen do more work and give more life to the beer in a shorter time than colder Kräusen.

The new practice has met with a speedy recognition, having been introduced with good results in many breweries.

Fermentation of a wort pitched at high temperature:

Thermometer in degrees F. and R.	49 7.5	51 8.5	51 8.5	51 8.5	51 8.5	51 8.5	51 8.5	48 7.0	45 5.5	42 4	39 3
Saccharometer in per cent	13.0	12.0	10.75	9.25	7.75	6.2	5.0	4.5	4.3	4.2	4.1
Period in days	0	1	2	3	4	5	6	7	8	9	10

In Kraeusen in 12--18 hours.

BOTTOM YEAST.

(See also Yeasts and Fermentation.)

The substance, by the agency of which fermentation is carried on is called yeast.

The course of the fermentation as performed by the yeast depends not only on the vitality and environment of the yeast, as age of yeast, temperature, aëration, composition of nutritive medium, presence or absence of other organisms, but also upon the type of yeast employed.

Types of cultivated yeast are distinguished by differences in the following properties possessed, or effects produced, by them:

1. Degree of attenuation;
2. Fermentative energy, or rapidity of attenuation;
3. Reproductive energy, or growth of yeast;
4. Rapidity of settling of yeast, or clarification of beer;
5. Qualities of beer obtained, as taste, odor, and durability. (See "Yeasts and Fermentation.")

The closest attention should be devoted to the yeast, as only by a sound, that is, pure and strong, yeast can a sound beer be produced.

CHARACTERISTICS OF A GOOD BOTTOM YEAST.

It has a thick, stiff, pasty consistency, not watery or slimy, a yellow to brownish color, a bitter taste due to hop-resin, and a characteristic odor.

It consists, for the most part, of single cell organisms of the class saccharomyces and species cerevisiæ. Yeast mechanically encloses a large amount of water, or beer—about 20 per cent—through which are dispersed minute bubbles of carbonic acid gas, that escapes when the yeast is stirred, emitting a rustling sound. After the beer has run from the fermenter, the yeast sediment should be quite firm and thick. However, unless an absolutely pure culture, every yeast has an admixture of foreign organisms, as bacteria, wild yeasts, and mycoderma. All these impurities may be classified as "potentially dangerous."

Since wild yeast or mycoderma cells do not settle so readily as culture yeast, the different layers of yeast in a fermenting vat *will not be found* generally to contain wild yeast or mycoderma *in uniform numbers.* Nor is the brewer safe in judging from th *absence of wild yeast* or mycoderma in the yeast sediment t

the beer is free from these obnoxious foreign organisms. Therefore an examination of the beer should always be made at the same time.

There are some admixtures that may be considered "harmless," as hop-resin and proteids, which give a deeper color, and crystals of oxalate of lime. (See "Micro-organisms.")

For microscopical examination of yeast as to strength and purity, see "Microscopical Laboratory."

KEEPING YEAST SOUND AND PURE.

Four essential points are to be considered in this respect. Proper nourishment, proper temperature, sufficient air, exclusion of adverse influences generally.

Neglect of these requisites may necessitate a change of yeast, that is, the introduction of an entirely new yeast by the brewer, the old yeast failing to perform its functions as desired, since the yeast may degenerate and become either too weak or too strongly contaminated to serve its purposes.

WEAK YEAST.

Symptoms of weak yeast are:

1. Watery or smeary condition, due to lack of carbonic acid;
2. Slow settling of the yeast in the vat, in the sample glass, and when watering or washing;
3. Poor "break" of beer;
4. Slow progress of fermentation;
5. Rim fermentation;
6. Rest fermentation;
7. Foxy fermentation;
8. Cold and bare spots in the Kräusen. (See "Abnormal Fermentations.")

It should be borne in mind that abnormal fermentations are not necessarily due to the weakness or impurity of the yeast. A microscopical examination is needed to decide this point.

NOURISHMENT OF YEAST.

The principal yeast foods in beer wort are the albuminoids and *certain mineral* salts. Of the albuminoids the amides are the *most readily* digestible, the peptones next, the albumose and in*soluble ones* not being available at all for this purpose. (See "*Nutrition*" under "Yeasts and Fermentation.")

Unfavorable conditions of yeast nutrition, that is, such as tend to increase the relative quantity of sugar or diminish the relative quantity of amides and phosphates, may be brought about by the following circumstances:

By using too much of raw cereals or sugar, which enlarges the quantity of sugar in the wort and diminishes the amount of albuminoids and phosphates.

By holding the mash at temperatures favorable to the formation of sugar too long, especially when the malt is rich in diastase.

Employing too high initial temperature whereby the production of amides and peptones is curtailed.

The preventives in these cases are self-evident (see Mashing Methods).

IMPROPER TEMPERATURES.

These may consist in:

- Allowing fermentation to take place below 41° F. (4° R.).
- Keeping the yeast without fermentation at higher temperatures (above 4° R.).
- Changing the temperature rapidly, for instance, pitching cold wort with yeast that was started in a warmer wort.

The proper temperatures for bottom fermentation are 42° F. (4.5° R.) to 51° F. (8.5° R.), or 49° F. (7.5° R.) to 51° F. (8.5° R.). (See also Temperatures under Yeasts and Fermentation.)

AERATION OF WORT AND YEAST.

Yeast requires air to carry on its vital functions. Oxygen should be supplied to the yeast in the wort to hasten fermentation, increase the yeast crop, and prevent degeneration.

Yeast seems to absorb a large amount of oxygen which it holds in reserve and utilizes during fermentation as it needs it. This free oxygen seems to be absolutely necessary for the yeast to carry on fermentation, and if not absolutely necessary for reproduction it certainly stimulates it and has generally a beneficial effect on the yeast. Excessive aëration is to be avoided, however, as under its stimulating effect the yeast may multiply excessively and take a corresponding amount of valuable substances out of the *wort, which, like the* amides, aid in giving beer fullness of body *and foam-holding* capacity. (See also Respiration under Yeast *and Fermentation.)*

Aëration can be supplied by:

- **Aërating the wort on the surface cooler or the Baudelot cooler.**
- **Aërating the yeast directly, or aërating the wort after pitching, or during fermentation.**

In all cases care should be taken to supply the yeast with pure air.

ADVERSE INFLUENCES GENERALLY.

Adverse influences to which yeast is most commonly exposed are:

- Frequent washing of the yeast especially with large quantities of water, or soft water.
- Long duration of fermentation.
- Letting the yeast stand under the beer or water too long.
- Keeping yeast in an inactive state too long from one fermentation to another.
- Employment of salicylic acid or other antiseptics in excessive quantities.

(See also Influence of Fermentation Products under Yeast and Fermentation.)

STRENGTHENING THE YEAST.

A yeast that has become weakened may be strengthened by one of the following methods:

BY FERMENTATION IN MALT WORT.

It should be put through fermentation in a pure malt wort from time to time. This is the most appropriate remedy where an excess of sugar in the wort is the cause that weakened the yeast.

ADDITION OF SALTS.

Certain salts like phosphate of potash and others may be unobjectionable for strengthening yeast when added while the yeast is being refreshed and developed for pitching. However, in view of the possible injury that can be done by addition of a wrong substance by mistake, it is best to avoid chemicals in any form.

DRUGS TO BE AVOIDED.

Many articles were used in former times in this connection, and there was much occult knowledge pretended to by brewers concerning them. Among these articles were nutmeg,

anise, cloves, saffron, cardamom, grains of paradise, coriander seeds, orris root, bay leaves, etc.

These and similar admixtures are for the most part quite indifferent, and in some cases injurious. They impart to the beer a peculiar odor. They should never be used.

The same may be said of alcohol or spirits.

Neither should malt flour be used in this connection, since such flour always contains bacteria. Nor does malt flour tend to strengthen the yeast. On the contrary, the diastase it contains, by changing the dextrin to maltose, increases the relative amount of sugar. There will, accordingly, be a higher degree of attenuation, accompanied by a tendency to weaken the yeast.

YEAST WATER OR BOUILLON.

A yeast water or yeast bouillon, or soup, may be used to advantage for strengthening purposes. To prepare it, boil six gallons of yeast with six gallons of water for half an hour, cool, let settle, pour off the yeast-water, about one-half of whole quantity, boil until flavor becomes agreeable, which may take a few hours, and add to six gallons of yeast, together with six gallons of first wort of a temperature of about 59° F. (12° R.), or finished wort. The active elements for the present purpose in this solution are large quantities of phosphates of potash and amides. (U. S. Patent of June 4, 1895, issued to R. Wahl and M. Henius).

ABUNDANT AERATION.

Finally, abundant aëration should be provided for the wort on the surface or Baudelot cooler, in the collecting or starting tub, before and just after pitching, or while refreshing the yeast for pitching. This aëration is not to be continued after the beer has come into Kräusen.

CONTAMINATIONS OF YEAST.

The principal agents of contamination are bacteria, mycoderma, and wild yeast.

Such contamination may be indicated in the brewery by: (1) Bad odor of fermentation. (2) Bubble fermentation. (3) Foxy fermentation. (4) Ropy fermentation. (5) Improper clarification of the beer in sample glass or chip cask. (6) Bad odor and taste of finished beer. (7) Impaired brilliancy and durability of the beer.

Foreign organisms reach the yeast from the air, from drippings from ceilings, through unclean vessels or utensils with which beer comes in contact. There is danger of infection wherever unfiltered air is permitted to reach the wort or beer, or where vessels are left uncovered, as fermenters, affording an opportunity for foreign matter to drop in.

Cleanliness, therefore, of the most scrupulous and exacting kind, is a prime necessity and the safest precaution for keeping yeast pure and sound.

SAFEGUARDS AGAINST CONTAMINATION.

Run the wort from the surface cooler as soon as it has cooled to 145° F. (50° R.). To leave it on the surface cooler after that point has been reached is to promote the development of foreign ferments, which have easy access to the beer, owing to the great surface exposure, and multiply rapidly at favorable temperatures. from 145-77° F. (50-20° R.). The air in the cooler rooms should be as pure as possible. Malt dust, street dust, etc., may become very dangerous at this point.

High fermenting varieties of yeast are not infected so readily as low fermenting.

Pitch with yeast directly after cooling.

Keep the yeast cool by attemperators or "swimmers" or brine pipes, never directly by addition of ice, which often contains impurities.

Protect the yeast, beer and wort from contact with impure air.

Prevent the drippings from the ceiling of the surface cooler room, and of the fermenting cellar, getting into the wort or beer. Protect the beer by inclined covers of canvas, wood or sheet iron hung over the fermenting vats.

Observe the strictest cleanliness. Thoroughly clean all pipes, conduits, vessels, floors, walls, etc. (See "Cleansing Operations.")

Low temperature is another important safeguard. The temperature should be kept down as much as practicable in all cellars.

NATURAL PRESERVATIVES.

Besides cleanliness and low temperatures, alcohol, carbonic acid, lactic acid and hop-resin are the natural perservatives of the yeast and beer, among which alcohol has special importance (See "Yeasts and Fermentation.")

TREATMENT OF CONTAMINATED YEAST.

Unless contaminated beyond hope of recovery, a yeast may be purified by the following means:

WATERING.

This may be used if the number of bacteria approximates 15 to 30 per 1,000 yeast cells.

Application: To 50 pounds of yeast add two gallons of pure cold condensed water, unless the natural water is absolutely above suspicion, to which has been added one ounce of gypsum (plaster of Paris). Stir well and pass through a very fine sieve—hair sieve—allow to settle while cooling by means of attemperator or brine pipes, never by adding ice. Pour off the water.

If the number of bacteria exceed 30 per 1,000 yeast cells, a change of yeast should be resorted to.

HIGHER FERMENTATION TEMPERATURES.

By employing higher pitching temperature or allowing the temperature to rise higher during fermentation, the culture yeast is enabled more effectively to rid itself of mycoderma or wild yeast or bacteria. (See "Yeasts and Fermentation.")

PURE YEAST CULTURE.

Several cells are separated from the rest under the microscope, the most suitable selected and propagated, according to the methods of Hansen, avoiding with absolute certainty infection from all possible causes, besides assuring the maintenance of the typical character of the yeast required for the desired fermentations. (See Pure Yeast Culture).

FACTORS AFFECTING FERMENTATION.

Fermentation, as has been repeatedly explained, is subject to modification by various factors, the most important of which are:

1. Amount of maltose;
2. Temperature,
   a. at time of pitching,
   b. as it rises during fermentation;
   c. time of holding highest temperature.
3. Amount of pitching yeast;
4. *Condition* of pitching yeast, whether weak or strong;
5. *Type* of yeast, whether of high or low attenuative power, whether slowly or quickly settling;

6. Aëration;
7. Presence of foreign bodies (abnormal fermentation).

DIFFERENCES IN ATTENUATION.

The effects of these factors on practical brewing operations may be again briefly considered.

(a) The larger the amount of maltose in the wort, (b) the higher the fermenting temperature, (c) the longer this temperature is maintained, (d) the stronger the yeast, (e) the stronger the aëration—(A) the higher will be the attenuation, (B) the greater will be the amount of alcohol in the beer, (C) the less will be the percentage of extract remaining in the beer.

The attenuation is also influenced by the amount of malto-dextrin in the wort.

Where a wort is very rich in sugar (sugar to non-sugar = 100:20, or sugar percentage 83.3), the saccharometer indication may fall from 13 B. to 2 B. Where the wort is unusually poor in sugar (sugar to non-sugar = 100:80, or sugar percentage 55), the saccharometer will fall from 13 B. to 6 B., and with abundant aëration, high temperature, and yeast of high attenuating type and extraordinary vigor, may be brought down to about $4\frac{3}{4}$ B. Attenuation depends, however, mainly upon the amount of sugar, and, secondarily, on the type of yeast employed.

The residue of sugar left in the wort at the end of the principal fermentation generally amounts to one-half per cent of maltose and 1 per cent of malto-dextrin for worts of average original gravity or about 10 per cent of the original extract. A yeast of high attenuating type, like Frohberg, gives an apparent degree of attenuation, which is about 10 per cent higher in a beer of ordinary gravity than where a yeast of the Saaz type is employed, other things being equal.

The difference in attenuation resulting from the employment of different yeast types is supposed to be due to the presence of an enzyme in the yeast of higher attenuating power, which has the property of inverting malto-dextrin to dextrose, whereas the yeast of low attenuating power does not contain this enzyme, or contains it in a smaller quantity or lower degree of activity. (See also Yeasts and Fermentation.)

An addition of malt flour to the beer or yeast increases *the attenuation*, because the diastase of the malt flour inverts *the dextrin of the beer*, during fermentation, to maltose, which

then ferments. This addition cannot be recommended on account of the danger of contamination, the malt flour containing many bacteria from the malt husks.

DURATION OF FERMENTATION.

(a) The higher the pitching temperature, (b) the higher the fermentation temperature, (c) the better the aëration, (d) the stronger the yeast, (e) the larger the quantity of yeast added, (f) the lower the percentage of sugar in the wort—the shorter will be the period of fermentation.

(a) The higher the pitching temperature, (b) the better the aëration, (c) the stronger the yeast, (d) the larger the quantity of pitching yeast—(A) the quicker will the beer go into kräusen, (B) the quicker will the saccharometer indication fall, (C) the quicker will the fermentation reach the high Kräusen stage, (D) the higher will the Kräusen rise.

FERMENTATION TEMPERATURE.

(a) The higher the pitching temperature, (b) the higher the percentage of sugar, (c) the stronger the yeast, (d) the greater the quantity of pitching yeast, (e) the better the aëration—the higher will the temperature of fermentation rise.

QUANTITY OF YEAST.

For every 100 pounds of extract fermented, about 15 pounds of new yeast is produced. Part of the yeast, equaling about one pound per barrel, goes with the beer on ruh, about 1 pound of yeast per barrel of beer is wasted, being the top and bottom layers of the yeast sediment, while 1 to 2 pounds per barrel is obtained of a quality suitable for pitching.

The better the aëration, the larger the percentage of sugar fermented, the more vigorous the yeast—the greater will be the new yeast crop.

The smaller the quantity of pitching yeast, the greater will be the amount of new yeast developed, since a small quantity of pitching yeast will yield as large a yeast crop as a large quantity.

INFECTION.

(a) The longer the wort stands without yeast, especially at higher temperatures, (b) the smaller the quantity of pitching yeast, (c) the weaker the yeast—the more favorable are the conditions for the development of foreign ferments.

HIGHER PITCHING TEMPERATURES.

The danger of infection is greatest before fermentation becomes active, since after the energetic action of the yeast has set in, foreign ferments have less freedom of development. It is therefore desirable to have the Kräusen rise as quickly as possible. This can be accomplished by pitching at higher temperatures than was customary in former years, starting at 49° F. (7.5° R.).

ABNORMAL SYMPTOMS IN FERMENTATION.

COLD OR BARE SPOTS.

In the stage of low Kräusen the entire surface of the beer is not always covered, but there may be openings in the head of foam.

The cause is weak yeast, or conditions tending to bring about a lowering of the temperature at the surface, like a cold draught of air.

BLADDERY OR BUBBLE FERMENTATION.

Large bubbles may be seen in the kräusen while they are collapsing.

Cause: Large amounts of finely divided suspended matter like starch, proteids and bacteria. When beer contains too little hop-resin, bubble fermentation may show more readily.

REST FERMENTATION.

In this case fermentation progresses but slowly and comes to a standstill while the indication of the saccharometer remains very high.

There may be several causes. 1. Too low a percentage of sugar in the wort. It may occur where the original Balling of the wort is high, but the ratio of dextrins is excessive. To prevent this, change the mashing method. To restore the defective wort to a normal condition, fill the fermenting vats half full with "green" beer just coming into Kräusen, and pump the beer showing rest fermentation to the Kräusen beer, adding one quart of cold extract of malt (for preparation see Starchy Turbidity of Beer), for every 50 barrels of beer. The diastase of the malt will first invert the dextrin and make the new sugar amenable to the influence of the yeast.

Cause 2 may be weakened or degenerated yeast, usually caused by too high a percentage of sugar in the wort, together

with a lack of amides and mineral substances. To prevent its recurrence, change the yeast and the method of mashing. To save the beer that suffers from rest fermentation due to this cause, mix it with equal parts of fresh Kräusen beer, without adding any malt extract.

BOILING FERMENTATION.

When the Kräusen begin to fall, the head of foam sometimes disappears, and the beer seems to boil up from the lower side of the fermenting vat, the bubbles of carbonic acid drift swiftly across the surface to the opposite side, the beer in the vat has gone into a rotary motion.

Cause: Unequal distribution of the yeast at the bottom of the fermenting vat, generally due to a strong inclination of the vat, and most frequently when the wort contains large quantities of sugar, also when the pitching temperature was too low, and too small a quantity of yeast is employed. An unequal distribution of yeast may be caused by rough wood or the presence of any foreign body in the vat.

Treatment: Rouse the yeast well from the bottom of the vat. A dressing with malt flour or common salt, which is sometimes recommended, is of no value. To prevent this abnormal fermentation occurring again, adopt another mashing method if the wort contains too much sugar, pitch at higher temperatures, and use more yeast.

RIM FERMENTATION.

After the Kräusen have fallen down, a rim of foam appears around the sides of the vessel, and the beers do not settle well.

Cause: Yeast clings to the walls of the fermenting vat, either because of a weak condition of the yeast, or because the wood is rough or not properly planed and varnished. Another cause is too rapid cooling of the beer before the Kräusen have properly collapsed, leaving too much sugar, which the yeast continues to ferment.

FOXY FERMENTATION.

The beer retains a muddy and reddish appearance, and will not settle.

Cause: Weak, light yeast, or wild yeast, or mycoderma, or much suspended matter of any kind, as starch, proteids and bacteria. Another possible cause is that the beer may have been cooled too quickly, when it still contained large quantiti

of sugar, the continued generation of carbon-dioxide keeping the lighter particles in suspension.

ROTTEN FERMENTATION.

This manifests itself by a foul odor arising from the fermentation, which is best observed by blowing into the Kräusen head.

Cause: Infection by bacteria of putrefaction. (See "Contaminations of Yeast.") For treatment see Bacteria Turbidity.

ROPY FERMENTATION.

In top fermenting beers. The beer becomes stringy or ropy.

Cause: Infection, usually by bacillus viscosus.

VACUUM FERMENTATION SYSTEM.

The important features of this system are:

1. The fermentation is conducted in closed glass enameled steel tanks, avoiding necessity of varnishing.
2. There is no contact with the atmosphere.
3. Sterilized air only is admitted, under perfect regulation during the fermentation.
4. Fermentation being conducted under a partial vacuum, there is a continuous removal of carbonic acid gas as fast as generated, which, together with admission of sterilized air, causes a continuous rousing of the beer.
5. The fermentation is completed within seven days from the kettle.

VACUUM FERMENTATION PLANT AND FITTINGS.

The special apparatus used in the vacuum fermentation system are as follows (see illustration):

1. Beer inlet with cap.—2. Pipe support for three-way fixture.—3. Gate valves for attemperator connections.—4. Air filter.—5. Air sight feed with glass.—6. Air check and stop cock.—7. Racking cock with strainer (formerly called spring racking valve).—8. Racking-off cock with cap and chain with half-inch air pipe connection.—9. Bracket for yeast valve support.—10. Manhole cover.—11. Beer outlet for bottom elbow.—12. Yeast strainer.—13. Top or large ear for manhole crab.—14. Bottom or small ear for manhole crab.—15. Crab, wheel and screw for manhole plate.—16. Testing cock with rubber nipple.—17. Thermometer.—18. Air cock with elbow for hose connection.—19. Three-way fixture for vacuum, gas and air connections.—20. Top cask connection. *The half-inch valve in the air pipe just above the air sight feed fixture is not shown in the marginal fittings, nor is the testing glass (bottle), used on testing cock.*

The dimensions of the tanks are as follows:

Inside diameter of all tanks, 7 feet 6 inches.—Outside diameter of all tanks, 8 feet.—Dish of tops and bottoms, 10 inches.—Height of each ring, 30 inches.—Height of legs, 18 inches.—Bottom of tank above floor, 7 inches.—Height of tank over all, three rings, 10 feet 2 inches.—Height of tank over all, four rings, 12 feet 6 inches.—Height of tank over all, five rings, 15 feet 3 inches.

The *capacity of tanks* is as follows:

Three-ring tanks hold full 85 barrels.—Four-ring tanks hold full 110 barrels.—Five-ring tanks hold full 135 barrels.

The following *cellar space* is required:

WEEKLY FERMENTING CAPACITY.

Three-ring tank	70 barrels
Four-ring tank	90 barrels
Five-ring tank	110 barrels

WEIGHT OF TANKS.

Three-ring tank	4,500 pounds
Four-ring tank	5,500 pounds
Five-ring tank	6,500 pounds

As far as *refrigeration* is concerned, it will then require ice-machine capacity over the cooler to 7° to $7\frac{1}{2}^\circ$ R., for cooling the vacuum cellar 22,000 cubic feet at 6° R., for cooling the beer, say, to 1° R., and for cooling the racking-room as usual. Estimates by experts place the ice-machine capacity required, complete, at thirty tons for such a plant.

The chip tanks and carbonating tanks are the same as the vacuum tanks, except that they are made of heavier steel and reinforced to stand excessive pressure. The fittings of these tanks are also of bronze, and specially adapted to their purpose. These tanks are steel, glass enameled.

FERMENTATION.

The preparation of the wort is identical with the method employed for wort intended for open fermentation. The wort is cooled to 46° to 49° F. ($6\frac{1}{2}^\circ$ to $7\frac{1}{2}^\circ$ R.), and run into the starting tub or directly into fermenting tank. Yeast is added as soon as cooling is commenced, and the quantity is 3 per cent of the total extract in wort in pounds, or about $\frac{3}{4}$ to 1 pound per barrel. *The temperature of the fermenting cellar is 43° to 48° F. (5° to 7° R.). If the wort has been run into an ordinary starting-tub, it is run or* drawn by vacuum into the fermenter as soon *as the Krausen* appear, generally in 12 to 16 hours. If the wor

has been run into the fermenter directly from the cooler it need not be drawn into another fermenter until the final stage of fermentation. The fermentation may also be finished in one fermenter only, if desired. When the beer has been collected in the fermenter, the vacuum is regulated to 15 to 18 inches, and this is maintained during the fermentation. The amount of filtered air desired to be passed through the fermentation can be exactly regulated and observed. The amount of air and the time for which it is to be admitted depend upon various conditions. The general practice is to admit the filtered air as soon as 15 to 18 inches of vacuum has been reached in the fermenter. The admission of air is continued generally for 48 to 96 hours. The temperature of the fermentation is allowed to rise to 51° to 53° F. (8½° to 9½° R.), depending on conditions and results desired. When about 90 to 95 per cent of the final apparent attenuation has been reached, lowering of the temperature is proceeded with in the usual way. The vacuum is maintained until the saccharometer indications remain stationary for six hours, when the vacuum is relieved by allowing filtered air to enter at the top of the fermenter. The fermented beer is allowed to rest from 24 to 48 hours, for the yeast to settle out, and for cooling to the desired temperature before running into the chip-casks, which is generally 36° to 39° F. (2° to 3° R.).

SAMPLE FERMENTATION.

	Wort at Pitching in Starting Tub.	1st Observation.	2d Obs.	3d Obs.	4th Obs	5th Observation.	6th Obs.	7th Obs.
		At Kräusen Stage. 14 Hours. Drawn Into Vacuum Tank.	38 Hrs.	62 Hrs.	86 Hrs.	110 Hours. Drawn Over Into Other Fermenter.	134 Hrs.	158 Hrs.
Temperature.	7⅛° R.	7¾	8¾	9	8¼	7½	6	3½
Per Cent. Balling....	13.2% B.	12.8	10.5	7.3	5.2	4.1	4.0	4.0
Vacuum	....	15 to 16 In. Applied.	On	On	On	On	Off	Off
Air	....	On	On	Off	Off	Off	Off	Off

ON CHIPS.

The treatment on chips is identical with that now in ordinary practice for stored beer. If the beer is intended for carbonating, it is cooled to 33° to 32° F. (½° to 0° R.), and this temperature maintained for 48 to 96 hours, depending upon the composition of the beer and the character of the yeast that has been em-

ployed in its fermentation. After being held at so low a temperature for the necessary time, it is filtered. Care must be taken that the temperature does not rise during filtration. The filtered beer is then forced through the carbonator and charged with the gas collected during the fermentation, and is then stored for 12 to 24 hours in a cask under pressure, and then racked off.

COLLECTING CARBONIC ACID DURING THE FERMENTATION.

About 12 to 24 hours before starting to collect gas the air is shut off, but the vacuum kept on. The vacuum-pump conveys the gas to a small cylinder. When the gas pressure in this cylinder reaches about 3 to 4 pounds, this pressure opens the steam valve to the compression pump. This pump forces the gas into steel cylinders to a pressure of 150 pounds, or more, if desired. If the gas pressure in the small cylinder falls below 3 pounds the steam valve on compression pump closes. In this way the gas collection works quite automatically.

CARBONATING.

The desired gas pressure in the carbonator, generally 23 to 25 pounds, is regulated by a reducing valve between the gas storage tanks. The back pressure on the carbonated beer is generally about 15 pounds. Of course, the pressures vary according to the desired quantity of carbonic acid gas the carbonated beer is to contain.

STORAGE CELLAR OPERATIONS.

The beer is ready for tanking when the principal fermentation is virtually finished. The marks by which that stage can be detected are the following:

1. Decrease in the indication of the saccharometer should still be from $\frac{1}{10}$ per cent to $\frac{1}{20}$ per cent during the last 24 hours.

2. The beer should have a good cover of fine, more or less dark foam. This protects the beer from contamination by contact with cellar air; therefore the cover should not be skimmed off more than once during or after the collapse of the Kräusen.

3. The temperature of the beer should be 39° F. (3° R.). This temperature is brought about by attemperators in the fermenters, or by running the beer from the fermenter to the storage vat through a cooler.

4. The beer should show a good break in glass. Held against the light, the small sample glass should show a lumpy condition of the yeast, balled up in little clots, between which the liquid in a thin layer should show translucent.

5. The yeast should settle in the sample glass at cellar temperature within 24 hours, the beer becoming entirely brilliant. The yeast should not settle on the sides of the glass. In a warm room it ought to settle in 3 to 4 hours.

6. The beer should look black when the cover is blown aside, showing that the yeast has settled well and left the liquid comparatively clear.

7. The beer should still contain some sugars, i. e., should not be completely fermented, in order to enable secondary fermentation to take place. During the previous 24 hours before tanking there should still be a slight attenuation.

8. Beer for export purposes—bottle beer—should not be allowed to settle too much, but rather be racked "green" than *clear ("lauter")*.

Before running the beer into the storage vats, the foamy head should be skimmed off with care, and then the liquid pumped without the least concussion or agitation of any kind.

The beer should be distributed into different Ruh tanks in order to secure a more uniform product both as to appearance and taste.

ON STORAGE ("RUH").

Storage, "Ruh," is that stage in which the beer is kept after the conclusion of the primary fermentation and prior to final clarification for the trade package.

The objects of resting the beer are to eliminate certain suspended matter, like yeast, securing greater clearness, and certain objectionable matters, like proteids, securing greater durability, especially in pasteurized bottled goods.

During the "Ruh" or storage period there should be a slight progress of secondary or after-fermentation. The residue of maltose and part of the malto-dextrin are fermented by slow degrees, the amounts of carbonic acid and alcohol increasing.

The yeast settles the more quickly, the less sugar there is present and the smaller the storage vats; and proteids are the more thoroughly eliminated, the better the mash was peptonized, the lower the storage temperature, and the longer the period of storage. Hence, long storage at low temperatures enhances the stability of beer after pasteurization.

Starch particles do not settle on Ruh. Nor can dependence be placed on improving the beer through long storage in respect to number of bacteria it contains. On the contrary, bacteria may increase during storage.

Low temperature, while the beer is in storage, is necessary to precipitate the proteids and to check the development of bacteria.

Keep the storage cellar as near to 32° F. (0° R.) as possible.

If the beer becomes brilliant on Ruh, that is, if after-fermentation comes practically to a standstill, bacteria will develop more easily.

If the beer is to be stored for a long time it should not be allowed to become so clear in the fermenting vat as when an ordinary beer is produced, but should be run into storage casks while still "green."

If the beer becomes clear on storage and we intend to store it *longer, it should* be kräusened with 3 to 5 per cent of Kräusen beer

and pumped into another Ruh tank. Another plan is to let the principal fermentation proceed as far as usual, and subsequently run in some Kräusen beer while the beer flows to the storage vats. This plan is recommended for beers designed to be very brilliant and remain in protracted storage.

If it is desired to bring the beer quickly on the market (city beer), add chips to the storage beer and also isinglass for preliminary fining.

For bottle beer, a high attenuating, slowly clarifying yeast should be employed.

For keg beer, a low attenuating, rapidly clarifying yeast is more suitable.

Export bottle beer should be stored three months; export draught beer six weeks.

During the storage period, hop-oils are partly converted into resins, the hop aroma diminishing accordingly.

CHIP CELLAR OPERATIONS.

THE BEER IN THE CHIP CASK.

When sufficiently matured in storage, the beer is run or pumped into chip casks, so called from a method of clarifying beer by means of chips (which see).

Treatment in the chip cellar has a twofold object.

1. To impart to the beer the necessary life, that is, a sufficient amount of carbonic acid gas so that it will foam properly when tapped. This is done—
   - a. by kräusening and bunging, or
   - b. by charging with carbonic acid gas directly (carbonating); or
   - c. by both kräusening and carbonating.
2. To make the beer brilliant. This is done—
   - a. by the addition of chips.
   - b. by the addition of isinglass.
   - c. by filtration.

KRAEUSENING.

This consists in the addition of Kräusen beer, that is, young beer in the first, or Kräusen, stage of fermentation, 24 to 44 hours after pitching, according to pitching temperature and amount of pitching yeast used. As to amount of extract and other constituents it differs but little from fresh wort, hence it changes the composition of the ripened beer. While the addition of Kräusen beer will cause fermentation to continue in the chip cask owing to the presence of fresh yeast, all of the sugar introduced by it will not be fermented.

The effects of kräusening, therefore, are:

1. The kräusened beer will have a higher percentage of extract, especially sugar. This has the effect of impairing the *durability of* draught beer, sugar being favorable to the growth of yeast.

2. The kräusened beer will contain a larger amount of hop-resin, the taste of the beer is accordingly changed, Kräusen beer being sweeter on account of sugar and more bitter on account of hop-resin.

3. The kräusened beer will contain more proteids which will impair the durability of bottle beer. Use sugar Kräusen for bottle beer.

4. The kräusened beer will contain a smaller percentage of alcohol.

5. The temperature of the beer will be raised slightly owing to the revival of fermentation and the higher temperature of the Kräusen.

6. Carbonic acid will be generated by the continued fermentation in the chip cask, which gas accumulates in the beer after bunging.

7. Young yeast cells are added.

The more energetic the cask fermentation, the more easily will the beer clarify. The young, vigorous yeast cells readily form clusters or lumps of yeast which will envelop, and, upon settling, carry down with them the smaller ones, together with bacteria and other suspended matters; thus, in part, at least, promoting clarification.

Kräusening is based on a principle similar to that which leads English brewers to "prime" beer in the trade casks by adding a strong solution of cane or invert sugar.

AMOUNT OF KRAEUSEN.

This is governed by the properties desired in the finished beer.

For shipping beers—draught and bottle beer (steamed)—that is, beers of which durability is required, not more than 8 to 10 per cent. For common draught beer, 15 per cent of Kräusen is generally used. These amounts vary, however, with the demands of the trade. In some cities as much as 25 per cent of Kräusen is added regularly to the city beer.

Where the taste is too bitter, use more Kräusen with less hops. Where the taste is flat, also use more Kräusen, but have them hopped as usual. If a beer is stubborn of clarification use more Kräusen.

Let the Kräusen foam work out of the bung-hole for three or four days. If the beer is bitter, continue for eight days.

The formation of a Kräusen cap over the bung-hole indicates *that the Kräusen* are working properly.

CLARIFICATION OF BEER.

Matter remaining in suspension at the end of the storage period is eliminated by mechanical means. First among them is the introduction of chips.

BEER CHIPS.

"Beer chips" or "clarifying chips" are pieces of wood so cut as to present a maximum of surface with a minimum of volume and weight.

Chips are made of varying lengths, breadth and thickness. Some brewers favor the very thin, curly chip, others prefer the straight, thicker and smooth chip, others again the corrugated chip. Metal chips have also been introduced, but since it is known that certain metals will produce cloudiness in beer, they should be employed with caution.

The chips clarify through the force of adhesion exercised by the surfaces of the same upon the small particles of matter suspended in the liquid.

PREPARING CHIPS.

Chips from young hardwood, beech or maple, are more effective than chips from old or soft wood. The wood should be well seasoned, i. e., well dried before cutting it into chips. The chips should then be boiled in plenty of water to remove coloring matter and woody taste, and one pound of soda is taken per barrel of water to remove the resin and make the wood more porous. Boil again with one-half pound of soda per barrel, a third time with one-quarter pound per barrel, then with water alone. If, after boiling for some time, the water remains colorless and without taste, and reacts neutral, the chips, after cooling, are ready for use in the chip cask.

Beer can be run twice on the same chips without removing them, then take them out and wash with cold pure water. After running beer on them twice again, wash them, first with cold water, and then with hot water, or boil them.

If the beer is infected, the chips must be removed each time after racking, and boiled each time after washing with cold water.

If chips that have been used are to be dried, they should *previously be well* washed and sprinkled liberally with a solu-*tion of bisulphite* of lime.

NUMBER OF CHIPS USED.

The number of chips to be put into the beer depends largely upon the degree of haziness of the beer. As a rule, the number should be the greater, (1) the younger the beer, (2) the more particles in suspension, (3) the finer the particles in suspension (bacteria, proteids), (4) if no filter is employed, (5) the larger the quantity of isinglass employed. Without filter the number of chips need not be more than 50 per barrel. If beers clarify with difficulty, use double that amount. With filter, use 5-20 chips per barrel, according to size of chip cask.

FINING THE BEER.

The process of brightening which proceeds naturally in storage, is further assisted artificially by fining the beer by means of substances which will rapidly precipitate suspended matter.

For this purpose prepared substances that contain animal gelatin are used. Such substances are obtained from fish sounds or from calf hide.

ISINGLASS.

From Fish Sounds.—These are the cleaned and dried swimming bladders of fish generally, principally of the sturgeon family; in the United States, from the hake. In the process of manufacture, they are first soaked in water, then rolled, and in rare instances starch is added for better appearance—gloss—and finally dried. This isinglass comes into the market in the form of thin shreds or ribbons. It varies in color from a deep yellow to almost white. There should be no odor or taste indicating decay.

From the Hide of the Calf.—This isinglass is manufactured according to Wahl's process. (See Brewing Materials.)

PREPARING THE FININGS.

There are two principal modes of preparing the article, as supplied by the dealer, for use in the brewery.

Warm Preparation.—Soak one pound of isinglass in 1½ gallons of cold, pure, soft water, renewing the water until every trace of odor has disappeared, washing the isinglass in the meantime by rubbing it lightly. At the expiration of about an hour add one-fourth pound of tartaric acid—for fish sounds—and keep stirring until no lumps are left. Add an equal quantity of boi

ing water, rouse well, mix with an equal quantity of beer, stirring to an intimate mixture, pour into the bung-hole of the chip cask, and stir gently.

With the tartaric acid the isinglass ought to swell considerably, and readily dissolve in the hot water. It is not advisable to dissolve it by steam, or to boil it, as the heat destroys the isinglass rapidly, particularly in the presence of acid.

Cold Preparation.—Soak in cold water and add acid and hot water, the same as for the warm preparation. When dissolved, add four gallons of cold water, rouse well; add gradually more water, and repeat this at intervals for 48 hours, adding as much water as the isinglass will take up. A good quality will take 30 gallons of cold water and keep its gelatinous consistency. This solution is mixed with beer, poured in through the bung-hole, and the beer stirred.

The isinglass may also be gradually thinned down without previous solution by adding small quantities of cold water until up to 30 gallons are obtained.

When using the cold process an addition of sulphite of soda should be made as the gelatinous mass is likely to mould.

Sounds.—If the sounds themselves are used in the brewery, they are soaked in cold water which is poured off, after softening. Then add one-half pound of tartaric acid per pound of sounds; when well softened cut up by passing through a sausage machine. Add cold water gradually, allow to soak thoroughly, and prepare warm or cold as above.

Wahl's Process Isinglass.—This does not call for tartaric acid, but after properly soaking in cold water (one pound per one and one-half gallons) for one hour, should be dissolved in hot water, after which it may be treated on the warm or cold plan like fish isinglass.

OPERATION OF ISINGLASS.

The process by which the isinglass acts is as follows: The gelatin contained in the isinglass dissolves in warm water and *precipitates in flakes* when cooled in beer when the solution is *sufficiently thinned out*, but in lumps, when the solution is too *oncentrated—therefore* the cold preparation is more effective *an the warm.* The flakes gather up the particles in suspension, *rying them* upwards during the escape of carbonic acid gas—

before bunging—and settling to the bottom with them, after bunging.

Prepared warm, the finings contain the gelatinous matter in true solution which, on addition to the beer, becomes insoluble. and settles in the form of a net enveloping the suspended particles and carrying them to the bottom, leaving the beer bright.

Prepared cold, the gelatinous substances are only in suspension and very minutely distributed, being insoluble in cold water. The more and the thicker a jelly the isinglass yields, the better is its quality for brightening the beer.

The quantity of finings to be used is dependent upon the extent and stubbornness and the nature of turbidity, and whether a filter is employed or not. Without a filter, use one pound to 40 to 60 barrels prepared warm, or one pound to 100 to 150 barrels prepared cold. When using a filter, one-half of this amount will be sufficient.

BUNGING.

After fining. the beer is bunged. that is, the bung-hole of the chip cask is closed tight for the twofold purpose of enabling the secondary fermentation which has been going on all the time, to charge the beer with the requisite amount of carbonic acid gas, and of promoting the sedimentation of whatever particles may still remain to cause turbidity.

If a bunging apparatus is used, the beer is usually bunged directly after adding the isinglass. If not, it is bunged as soon as it has become moderately fine.

After bunging, the carbonic acid gas generated in the chip cask cannot escape. The beer grows richer in carbonic acid gas and exerts a pressure on the inside of the cask. The more carbonic acid is generated, the higher will the pressure rise. The higher the bung pressure, the colder the beer, and the higher the percentage of extract, the more carbonic acid will accumulate in the beer.

The augmenting pressure in the chip cask facilitates the precipitation and settling of particles in suspension.

When not using racking apparatus, beer should be bunged with from 4 to 5 pounds' pressure, and rather less with racking ap paratus. If the beer is bunged with more than 5 pounds' pr sure it is apt to foam, if not very cold, when racking. If the beer contains too much carbonic acid gas it will no

the foam so well as if it had its proper quantity. If the beer contains too much carbonic acid gas the individual bubbles that make up the foam will be larger than if the foam is creamy, and breaking up more easily, the foam will collapse quicker.

RACKING.

The finished beer is racked off, that is, run into the trade packages (barrels, kegs, etc.).

This is done by means of air pressure, the racking bench usually standing higher than the chip cask, a steady flow of beer under an invariable pressure should be maintained, avoiding jars or concussions, sudden stoppages, etc., as otherwise too much carbonic acid gas will be lost and the yeast might rise in the chip cask, making the beer turbid.

The quantity of carbonic acid gas that beer contained at various stages was found to be (laboratory of Wahl & Henius):

After principal fermentation	0.20 per cent.
After two months' storage (in lower layers)	0.35 per cent.
After racking from storage in chip cask	0.28 per cent.
Before racking from chip cask	0.40 to 0.42 per cent.
In the kegs	0.35 per cent.
In the glass	0.28 per cent.

If the beer contains less than 0.30 per cent of carbonic acid in the keg or bottle, or less than 0.25 per cent in the glass, its taste will be flat.

There are modern devices for preventing foaming while racking by maintaining a counter-pressure on the flowing beer, yielding to the forward pressure sufficiently to allow the liquid to flow, but offering too much resistance to allow foaming. This is applied both to kegs and to bottles. In some cases the counter-pressure is exerted by carbonic acid, preventing contact of the beer with atmospheric air until the trade cask is tapped, thereby minimizing the chances of infection and adding to the stability of the product.

CHILLING THE BEER.

It is advisable, whether a racking device is used or not, to chill the beer on its way from the chip cask to the filter, reducing the temperature of the beer below the freezing point of water. It

beers contain an abnormally high percentage of proteids the low temperature may render them insoluble, when the filter may remove them, this process yielding a more stable beer when bottled and steamed. If beers contain but little proteids the time of passage through the cooler is too short to precipitate any appreciable amount of them.

CARBONATING.

By charging the beer with carbonic acid (carbonating), the detrimental influences of kräusening are avoided. It is difficult, however, to treat beer uniformly according to this method, or to produce beer with creamy head without addition of Kräusen or sugar solution at the same time.

The carbonic acid in carbonated beers is generally introduced into the beer on its way from the chip-cask to the filter. It has been found impracticable, if not impossible, to carbonate Ruh beer from the storage tanks directly, one reason being that in such beers the carbonic acid is not uniformly distributed, the amount being larger in the bottom than in the top layers. In order to be successfully carbonated the beer is usually run into a chip cask where a small percentage of Kräusen is added, and after bunging long enough to raise a slight pressure it is passed through the carbonator.

FILTRATION.

The latest and a most efficient artificial aid to clarification is the beer filter (see filters). It has come into general use of late years. The beer to be filtered need not be so brilliant in the chip cask as where no filter is used.

The process of filtering beer consists in forcing the beer, generally by means of air pressure applied at the chip cask, through one or more layers of compressed fibrous material, called filter-mass, which commonly consists of wood pulp or paper pulp. The thicker the layer of pulp, and the stronger it is compressed, the more effective will the filter be in removing turbidities, but the slower will be the process of filtration. By means of filtration yeast cells, both of culture yeast and the different varieties of wild yeast, and mycoderma cells can be removed. If the filter material is of fine texture (mixed with asbestos fibe and compressed very hard, bacterial and proteid turbidities be effectively treated, whereas starchy turbidity, owing t

minuteness of the particles in suspension, cannot be removed by filtration.

The advantages of filtration are:

1. Greater brilliancy and consequent greater durability of the beer.
2. Saving in chips and isinglass, as well as the time, labor and utensils employed during that stage.
3. Doing away with beer remnants and their treatment, as a filter will allow the last residue of beer to be clarified and used.

The filter is inserted between the chip cask and the racking bench, the beer in its flow from the former to the latter being forced through the same.

FILTERING OPERATIONS.

Beer should always pass through the filter under back pressure, as it will otherwise foam to such an extent as to preclude the proper filling of the trade packages.

In cases where there is no back pressure racking apparatus, it is advisable to place the racking bench higher than the filter and chip-cask in order to produce a natural back pressure action, and prevent foaming. For the same reason, and in order to get a uniform flow of the beer to be racked, the hose connecting the filter with the racking bench ought to be at least 50 to 100 feet long, and handled so as not to form any sharp corners. The hose may be of one to one and one-half inch diameter, according to the size of the filter and the racking capacity desired. By increasing the size of the hose the racking capacity may be increased considerably.

The filter ought to be put in a cool place and if practicable, in the chip cellar. Several pounds' pressure is necessary for the passage of the beer through the filter to the racking bench. The pressure from the chip-cask is regulated according to the flow desired, and is limited by the degree of air-tightness of the casks and their soundness, and may reach 10 to 20 pounds. During the time when the filter is not in use it ought to be filled with cold, *pure, iron-free* water, preferably condensed or boiled water.

After the connection between the chip-cask, filter and racking *bench is established*, and the valve of the chip-cask is opened, water *is allowed* to escape till beer appears, and the operation of fil-

tering properly started. A little foaming invariably takes place at the start, and the foaming liquid is let off till the beer begins to flow clear. Where the hose leading from the chip-cask is connected with the filter an observation glass will do good service, which should be supplied with an automatic appliance for closing the filter inlet as soon as the cask is emptied and air gets access to the flowing beer. This is usually effected by a rubber ball floating in the liquid in the glass cylinder, and settling in the outlet as soon as the liquid is displaced by air.

Racking into barrels at the bench is started as soon as the beer begins to flow clear. Care should be taken not to interrupt the flow of the beer as the filtering material would otherwise give off some of the retained particles and cause turbidity for a few minutes.

OBSTINATE TURBIDITIES.

It happens, occasionally, that turbidities will not yield to the ordinary treatment, and special treatment then becomes necessary, which should be governed by the nature of the turbidity. In all cases of obstinate turbidity an energetic chip-cask fermentation, obtained by using more Kräusen or sugar—or glucose—Kräusen will be found effectual. At the same time the filter mass should receive an admixture of fine asbestos fiber, and be packed tighter to make it more effective. In this way wild yeast, bacteria and proteid turbidities are practically removed.

STARCH TURBIDITY.

When kräusening the beer, add one quart of cold extract of malt ("Kalter satz") to 50 barrels of beer.

To prepare this cold extract of malt: To 20 pounds of crushed malt add 10 gallons of cold water, stir well for 10 minutes, allow to settle for one-half hour, pour off the liquid through a flannel cloth, bring the thick malt upon the flannel, and allow to drain. Of the liquid so obtained add one quart to 50 barrels of beer, preferably when kräusening.

PROTEID TURBIDITY.

This form of turbidity often disappears upon warming the beer slightly, so that it often happens that it is cloudy in the cellar and has become entirely brilliant, when tapping in the saloon.

If the beer is very cloudy, sugar Kräusen should be used for treating it (see Preparation of Bottle Beer).

Beers showing proteid turbidity should never be used for pasteurized bottle beer.

ABNORMAL TASTE AND ODOR OF BEER.

There are times when notwithstanding all precautions have been properly taken—at least the brewer so thinks—the finished beer will possess an abnormal taste or odor, making it unsalable or at least less palatable. In such cases the important thing to do is to go over the whole course of manufacture in the most searching manner, to discover at what point a mistake was made, and take measures to forestall any repetition of the calamity.

For the immediate purpose of saving the imperfect beer and making it as sound as possible, prompt and drastic measures are required. Wherever possible, natural means should be employed, and the use of chemicals avoided, and in most cases it will be found that sugar, hops, a hopped sugar solution or more or less Kräusen, more strongly or more weakly hopped, as the case may warrant, will prove effective, will cure the evil by returning, as it were, to an earlier stage and going through the various processes once more, with an eye single to the removal of the existing evils.

Among the tastes and odors of most frequent occurrence, representing deviations from the desired properties of the beer, the following may be mentioned:

BITTER TASTE.

This may be caused by the use of too much hops, especially Western or Pacific Coast hops, which are frequently found to give beer a rank, bitter after taste if used in large quantities. Not more than half of the hops used should consist of Pacific Coast hops if the amount used is over one pound per barrel. Blending hops grown in different localities will be found productive of good results.

Other causes that may lead to an unpleasant bitter taste are, (2) boiling the hops too long; (3) leaving the wort standing too long in the hop-jack, or (4) the presence of wild yeast.

Treatment: The beer in the chip cask should be treated with more than the usual amount of Kräusen, less strongly hopped

SWEET TASTE.

An excess of sweetness, or too mild a taste, may be caused by too much sugar, or an insufficient amount of hops.

Treatment: The beer in chip-cask should be treated with less Kräusen, strongly hopped.

HARD OR TART TASTE.

This is caused by too much acid, usually lactic acid; such beers are also difficult of clarification.

Treatment: The beer should receive an addition of soda—not bicarbonate of soda, as this will make the beer foam too much—to neutralize the acid. The amount to be added depends on the degree of acidity. In some localities the addition of soda to the beer is a general practice in order to give the beer a milder taste.

ONION TASTE.

This is due to a peculiar condition of the yeast, some varieties giving rise to it more quickly than others. The yeast may at the same time be entirely pure. Change your yeast at once, as soon as this taste or smell becomes noticeable.

CELLAR TASTE.

Beers will readily take up any foreign odor, as when in contact with wood or pitch, poor varnish, or when the cellar air has a rotten or foreign odor like that of asphalt from a freshly laid floor, or tar from tar-paper used as an insulating material between the walls. Beer should, therefore, be carefully protected from contact with any such odor either in a vessel or in the air. A brewer should also avoid the employment of any substance in the cellars that has a foreign odor, for instance, substances for disinfecting or for cleaning purposes like carbolic acid and chloride of lime.

STABILITY OF BEER.

A beer which is expected to possess durability should have as few particles as possible in suspension. It should be perfectly brilliant.

A distinction should be made between:

1. Stability of pasteurized bottle beer (export bottle beer).
2. Stability of not pasteurized beer (export draught local bottle beer).

If pasteurized beer becomes turbid, it is usually proteid turbidity, otherwise the beers have not been properly pasteurized. (See "Bottling Department.")

If keg beer or not pasteurized bottle beer becomes turbid, it is usually yeast turbidity.

If beer kept for a certain time shows any other turbidity outside of these two characteristic turbidities, it was not racked off in a sound condition, or it was infected by foreign organisms in keg or bottles due to improper cleaning of the same.

A sound beer filled into clean packages should not become sour or show a turbidity due to foreign organisms.

PASTEURIZATION OR STEAMING.

This is a process designed to give greater stability to beer. (See also "Bottling Department.") In general outline it consists in heating the finished beer in bottle to a temperature sufficient to kill such yeasts and other organisms as may remain in the liquid, excluding the light during this process, after which the beer is cooled.

The problem that presents itself in this treatment is to reach and hold a sufficient heat to accomplish the destruction of all germs without materially affecting the beer itself as to taste or brilliancy, or causing too much loss by breakage of bottles. Various devices have been constructed for steaming. No altogether satisfactory method of pasteurizing beer in kegs or casks or otherwise in bulk has yet found its way into brewery operations.

SPECIAL AMERICAN BOTTOM FERMENTATION BEERS.

EXPORT BOTTLE BEER.

At every step from the purchasing of the barley to the proper putting up into packages and storage, of the pasteurized beer, all precautions should be directed toward getting rid of the proteids. (See "Principles of Brewing.")

In a general way, superior material must be used for bottle beer to what is necessary for keg beer, or any brand designed for immediate consumption. The reason is that bottle beer is calculated to be kept longer and under more trying conditions, going quite commonly into residences or otherwise into private use where there are none of the facilities for giving beer appropriate treatment, such as a well appointed bar-room possesses. The adverse influences to which beer is exposed in transit during long journeys also count in this connection.

DIRECTIONS FOR PREPARING PALE OR EXTRA PALE BOTTLE BEER.

Materials: Take only a choice pale malt, well grown, i. e., about 90 per cent of the kernels should have the acrospire developed to three-quarters or the whole length of the kernel, and the barley should contain only a limited number of glassy and half-glassy kernels. The malt should have been stored for three months, having been carefully treated in the dry-kiln by preliminary drying on the upper floor at a low temperature, i. e., not to exceed 100° F. (30° R.), and thorough airing during this process, followed by a final temperature on the lower floor of not less than 167° F. (60° R.). (See "Kilning Operations.")

Use only best quality of rice free from any musty smell and *free from foreign seeds*, or best quality of grits or flakes *containing not more than* 1 per cent of oil, nor more than 13 per cent *of moisture*, or corn starch.

For methods of mashing and boiling see "Mashing and Boiling Operations."

Fermentation: The wort is pitched with 1¼ pound of yeast per barrel at 45.5° F. (6° R.) and temperature allowed to rise to 59° F. (8½° R.), then cooled to 39° F. (3° R.).

The storage cellar should be kept as near to freezing point as possible, the chip cellar between 34° and 36° F. (1 to 2° R.).

Storage.—The beer should be stored for three months.

Chip Cellar.—Treat the beer in the chip cellar as usual, but with the exception that sugar Kräusen should be employed instead of common Kräusen. The Kräusen should be prepared and used according to the following method, viz.:

Sugar Kräusen.—In 20 barrels of boiling water in hop, or rice-kettle, dissolve 600 pounds of anhydrous grape sugar, boil for 15 minutes, add 30 pounds of fine American or imported hops, boil for 15 minutes more, run into hop-jack, cool to 55° F. (10° R.), add two pounds of yeast per barrel and allow to come into Kräusen. (In about 24 hours a fine white foam will appear.)

Now add to the beer in the chip-cask 10 per cent of these hopped sugar Kräusen, or five barrels per 50 barrels of beer, allow to work out of the bung-hole for three days.

For treatment of beer in bottling department see that head.

EXPORT DRAUGHT AND UNSTEAMED BOTTLE BEER.

Where beer is intended to keep for some time without being steamed, as in the case of keg beer shipped out of town or unsteamed bottle beer, certain points require particular attention:

1. The beer should be perfectly brilliant when racked off into the trade package; especially should it contain the least possible number of yeast cells and bacteria.
2. The beer should contain a proper amount of alcohol and as little sugar as possible.
3. It should be stored at a low temperature.

The less alcohol the beer contains when racked, the more sugar the beer contains when racked, the more yeast cells it contains when racked, and the higher the storage temperature after racking—*the sooner it* will become turbid and form a sediment.

An export draught beer should contain approximately 4 per *cent of alcohol.*

In order to reduce the amount of sugar to the lowest possible point:

a. The temperature of the principal fermentation should be allowed to rise to 51° F. (8.5° R.).

b. The beer should be stored for at least six weeks.

c. Kräusen with the smallest amount possible—about 10 per cent. Sugar Kräusen should not be used.

d. Let the beer work out of the bung-hole for 10 days, filling up with fresh Kräusen every day or two. Then fine and keep under five pounds' pressure for four weeks at least before racking.

e. Keep the chip cask cellar at a higher temperature than the Ruh cellar, viz., at 36½-39° F. (2-3° R.).

f. Use warmer Kräusen—51° F. (8½° R.)—i. e., pitch the Kräusen brew at a higher temperature, 49° F. (7½° R.). Preferably add to the beer about 5 per cent of Kräusen and carbonate it.

g. More chips should be used and the beer fined with more isinglass than usual, and it should then be filtered.

MALT TONICS.

These beers are made of a dark color, some having the general characteristics of a heavy-brewed Bavarian beer, like Kulmbacher, for instance, with a pronounced malt flavor and sweetish taste, a high percentage of alcohol and relatively small percentage of extract; others having the same general characteristics but a low percentage of alcohol and high percentage of extract. The latter type is brewed and fermented like the former, but receives a larger percentage of Kräusen, or wort, in the chip-cask.

Malt tonics are generally put up in bottles, attractively labeled and usually distributed by druggists. If such tonics are advertised for use for medicinal purposes and so sold by the retailer in good faith, and not as beverages, and if they really are medicinal preparations, the druggist will not require the United States retail liquor dealer's license to sell the articles. The mere addition of a drug used for medicinal purposes is not sufficient to exempt the dealer. As to such licenses as he may require under state or municipal laws and ordinances, local regulations must be consulted. (See "Legal Relations.")

Materials: High-dried malt with caramel malt, black ma

or roasted corn, in quantities to suit color. hops from 1¼ to 2 pounds per barrel, according to flavor and degree of bitterness desired.

Strength of Wort: 16 to 18 per cent Balling.

Method of Mashing and Boiling. (See "Pure Malt Beer.")

Method of Fermentation and Storage. (See "Bottle Beers.")

Treatment in Chip-cask: Use from 15 to 30 per cent of Kräusen, and if low percentage of alcohol and high percentage of extract is desired, add in chip-cask a corresponding amount of wort.

Treatment in Bottling. (See "Bottling Department.")

TEMPERANCE BEER.

By this term certain beverages are known which are intended to be sold in districts where the sale of intoxicating liquors is prohibited. The percentage of alcohol is reduced so as to make the beverage non-intoxicating. (See "Legal Relations.") Such beers are usually produced from a wort of 6 to 8 per cent Balling, containing no more than 4 per cent of reducing sugars.

Materials: Pale malt with or without unmalted cereals or sugars.

Mashing Method: Wahl's Lauter-mash method will give good results (see "Mashing Operations") where a brew is specially made; otherwise the spargings of an ordinary brew may be used together with glucose containing a high percentage of dextrin. Add one-half to three-quarters pound of hops per barrel in kettle. tle.

Fermentation: Add three-quarters pound yeast per barrel at 45° F. (6° R.), let rise to 48° F. (7° R.), cool to 39° F. (3° R.), store one week.

Treatment in Chip Cellar: Kräusen with 15 per cent of temperance Kräusen and treat beer as usual or carbonate.

Treatment in Bottling. (See "Bottling Department.")

CALIFORNIA STEAM BEER.

This beer is largely consumed throughout the state of California. It is called steam beer on account of its high effervescing properties and the amount of pressure ("steam") it has in the packages. The pressure ranges from 40 to 70 pounds in each trade package, according to the amount of Kräusen added, tem-

peratures, and time it takes before being consumed and the distance it travels from saloon rack to faucet, etc. Usually 50 to 60 pounds' pressure is sufficient for general use.

Strength of Wort: 11 to 12½ Balling.

Materials: Malt alone, malt and grits, or raw cereals of any kind, and sugars, especially glucose, employed in the kettle to the extent of 33⅓ per cent. The barley is malted as for lager beers. Roasted malt or sugar coloring is used to give the favorite amber color of Munich beer.

Mashing methods vary greatly. Some brewers employ English mashing methods, but the double mashing methods employed in a great many lager beer breweries, starting with low temperatures, in fact, mashing as though for lager beer with the exception of stopping and mashing at 158° F. (56° R.) until all is converted, will give very good results. But as a rule the initial temperatures are taken about 140° to 145° F. (48° to 50° R.), then to 149° to 154° F. (52° to 53° R.), mash 10 to 15 minutes, and then raise to 158° F. (56° R.) as final temperature.

The raw cereals are cooked and added in the same manner as if conducting a lager beer mash.

The mash is allowed to rest about 45 minutes, and the same precautions taken in running off wort and sparging as in other mashes, the sparging water to be about 167° F. (60° R.).

The hops used depend upon the quality. Of a good quality, three-fourths of a pound per barrel is used and added in the usual way.

The wort is boiled as soon as the bottom of the kettle is covered, and after the kettle is filled, boiling is continued for one to two hours. The wort is then pumped to the surface cooler, and then over the Baudelot cooler and cooled to about 60° to 62° F. (12° to 13° R.). In breweries where no cooling apparatus is used, the wort is exposed over night, or until it is cooled to about the above temperature.

Fermentation: The wort is now run into tubs of the starting tub style and size, where it is pitched with about one pound per barrel of a special type of bottom fermenting yeast, and well aerated. In about 14 hours a thick, heavy Kräusen head appears from which the beer to be racked off is Kräusened. The temperature of the beer is now about 2° to 3° F. higher or about 62° to 63° F. (13° to 14° R.) if pitched at 60°. A

Kräusen have been taken it is run into long, wide shallow vats, called clarifiers, which are made of wood, about 12 inches high. Precautions should be taken that clarifiers, in which the beer stands six to eight inches high, are not too cold, so as to give the wort running out of the tubs a sudden set-back which may check fermentation. This can easily be avoided by sprinkling the clarifiers with hot water previous to letting wort run.

The wort then ferments in the clarifiers for two to four days. Precautions are taken against exposure to sunlight, and the fermentation should not rise too high. The matter which rises to the top is skimmed off continually.

When indications are the same as in lager beers, viz., dark color, yeast well settled, good, clear break, etc., it is ready to be racked directly into trade packages, or if for some reason it is deemed expedient, it may be racked into small casks of 5, 10, 15 or 20 barrels' capacity and kept there at a moderate temperature until wanted, then Kräusened and racked off. If racked off directly from clarifiers, the Kräusen is added with a quart measure to the trade packages, according to the amount of carbonic acid desired, the weather, etc., usually about five gallons per one general trade package called one-half barrel or 15 gallons, or, in general, about 33 to 40 per cent.

Finings are also added to each keg in about the same proportion as for lager beer. Trade packages are then gone over with a special filling can, filled completely and closed with iron screw bungs, when after two days it is ready for shipment. It should, as a rule, be about 5 or 10 days old before leaving the brewery, when it has attained the necessary pressure. In the saloon it is laid up for two days to allow settling, the bung being opened, as a rule, over night, to allow just a small amount of gas to escape, so as to be able to draw from the faucets without getting too much foam. This is done if drawing directly from keg, while, if using beer apparatus, "steaming," as the escape of the gas is termed, is unnecessary.

If this beer is properly brewed and handled it makes a very clear, refreshing drink, much consumed by the laboring classes. It will keep for some time in trade packages, i. e., from 2 to 6 months, but is usually brewed and consumed within a month or *three weeks*

PENNSYLVANIA "SWANKEY."

This beer has a local reputation in some parts of Pennsylvania, and is still brewed in Allegheny. It may also be classed as a temperance beverage, containing but little alcohol. Its name is probably a corruption of the German "Schwenke."

The material employed is malt. Balling of wort, about 7 per cent, hops about one-half pound per barrel, and a flavoring condiment like anise seed.

The malt is doughed-in at 167° F. (60° R.), and the mash held at 154° F. (53½° R.) until inverted.

The hops are boiled one to two hours, the condiment about 30 minutes.

The pitching temperature is about 61° to 63° F. (12° to 14° R.). The beer is run into puncheons as soon as the Kräusen begin to fall, is allowed to spurge out, and is topped up every few hours, until the Balling of beer is about 5, when the beer is racked into trade packages and stored at about 61° to 63° F. (12° to 14° R.), until it has raised sufficient life, when the beer is cooled to about 42° to 45° F. (5° to 6° R.) and marketed.

Cream, Lively or Present Use Ale, Still or Sparkling Ale, American Stout, Porter and Stock Ales, American Weiss Beer, Kentucky Common Beer, will be found under "American Top Fermentation Beers."

PRODUCTION OF THICK MASH BEERS IN GERMANY AND AUSTRIA.

The data on this subject were mainly taken from Thausing's "Malzbereitung und Bierfabrikation," 1898.

PROPERTIES OF THICK MASH BEERS.

(See also "Malting in Germany.")

Bavarian beer is light-brown (like the Munich) to dark-brown (like the Kulmbacher). It has palate-fulness, a sweet taste and malt flavor. Balling of wort about 12.5 to 14.5. Export and Bock about 15 to 18. On account of the pronounced malt taste the beer should be but lightly hopped.

Bohemian beer (like the Pilsener) is light-yellow to greenish-yellow, the taste is vinous, dry, somewhat sharp; instead of the malt taste, the bitter taste of hops predominates. The light Bohemian "Abzug," or "Schenk" beers are brewed 10.5 to 11.5 Balling, and are racked either in a clear condition or kräusened (Hefenbier). The lager beers, usually from worts of 12.5 per cent, are as a rule not kräusened.

Wiener beer as to taste, amount of hops and color takes a middle place between the other two.

The lager beer is brewed 13.5 Balling, the "Abzug" beer, which is racked soon after fermented, about 10.5. Wiener "Märzen" and export beers about 14.5 to 15.5 Balling.

THE DECOCTION OR THICK MASH METHOD.

According to Thausing modern beer in Germany and Austria is brewed according to the decoction method with three mashes, while formerly three different systems were distinguished and known as the Vienna, the Bavarian and the Bohemian. This *distinction has* become obsolete, since at present in Austria, especially in Vienna, as well as in Bohemia and Germany the decoction method with three mashes is universally employed. Here

and there slight changes are made in certain breweries in regard to the temperature periods and the time of boiling the mash without, however, any perceptible differences in results as to the character of the beer.

The initial or doughing-in temperature is about 28° to 30° R. (95° to 100° F.). If hot water is run in, it should be done slowly and while keeping the mashing machine moving, so that this proceeding will take 15 to 20 minutes.

Three parts of the whole mash are successively boiled and called the first, second and third mash, each for 10 to 45 minutes. In Bohemia, where pale beers are the vogue, boiling is often restricted to 10, 15 or 20 minutes, in Vienna generally 30 minutes, in Bavaria often 45 minutes.

As to heating the mash in the kettle, experience shows that this should not be done too quickly, but that on the other hand, it is not only a waste of time, but also may impair the quality of the beer, if the mash is left for a prolonged period at low temperature, i. e., heating it too slowly. This heating is governed to a certain extent by the qualities of the malt. The method of heating is most important with the first mash, which, in the three-mash process, is run into the mash kettle at a temperature of 28° to 30° R. (95° to 100° F.), and there frequently raised to 40° to 45° R. (122° to 133° F.) by the remaining water.

This thick mash is then raised in 20 to 30 minutes to 60° R. (167° F.) and in 10 to 15 minutes more to a boil. To prevent scorching, the stirrers must be kept going until boiling begins. Where imperfect stirring devices are in use the temperature is not uniform throughout the mash, but higher at the bottom and near the sides than is indicated by the thermometer in the mash.

Enough of the thick mash was run into the pan to bring the total mash in the mash tun (first mash) to 40° to 42° R. (122° to 126.5° F.) by pumping it over. The mash should be pumped neither too fast nor too slowly. What is said about heating the mash applies here as well. About 15 minutes may be taken for this work.

The mash having been well worked through, a sufficient quantity is again run into the mash kettle so as to bring, upon return, the total (second) mash to 50° to 52° R. (144.5° to 149° F.). Part *of the first mash* having remained in the pan the second ma[sh] *generally has* 50° to 55° R. (144.5° to 156° F.) at once w

reaching it and can be so heated that it comes to a boil in 15 to 25 minutes, according to the malt.

The first two mashes are thick mashes. By keeping the mash machine going while the mash runs into the pans, much of the thick part of the mash passes into the pans. Brewers formerly were particular to boil very thick mashes, thinking thereby to make the beer very full to the palate. The third mash is generally a "lauter" or thin mash. Before running it from the tun the mash is allowed to rest for a while, permitting the solid parts to settle to some extent, whereupon the mash is run off so as to get as much clear mash as possible into the kettle. Brewers used to put a strainer before the outlet and, in some brew-houses, to drain off the "lauter" mash through the false bottom. At present, the distinction between thick and "lauter" mashes is not often made, and frequently three thick mashes are purposely boiled.

The third mash is brought to a boil as quickly as possible, usually in about 15 minutes. The quantity is to be taken so that the main mash reaches 60° R. (167° F.) by pumping up the "lauter" mash from the pan. This last operation is called "final mashing." It is followed by pumping the mash into the strainer (Läuterbottich), where it is kept in motion for some time by crutches or stirring machine to enable the grains to settle uniformly.

The decrease of diastatic power in the decoction mashes according to Lintner is considerable. (Zeitschrift f. d. ges. Brauwesen, 1888, p. 317.) If this power at 28° R. is designated as 100, it was found to be 61.1 at 42° R., 26.8 at 49.8° R., and only 26.8 during the straining period.

The mash having been brought from the mash-tun to the strainer (Läuterbottich) is left to stand. Then the wort is strained and the grains sparged, using the same general precautions already described for the respective processes in the production of American lager beers.

The wort is generally boiled in the kettle until it shows a good "break," then one-half of the hops is added, and after one hour's boiling the second half, which is boiled for an hour to an hour and one-half more. Total length of boiling with hops, two to two and one-half hours. Sometimes one-half of the hops is added as soon as the wort boils, one-quarter after one hour, the last quarter one hour before running out.

According to Thausing (Malzbereitung u. Bierfabr., 1898, p. 609) the amount of hops used for the different types of beer is generally given per hectoliter (about 25 gals.) of wort, mentioning the saccharometer indication of the wort.

For Bavarian beer, to one hectoliter beer of 12.5 to 14.5 per cent, hops to the amount of 0.20, 0.28 to 0.30 kg. are used.

For Vienna beers the quantities of hops per hectoliter used are as follows (1 kilo = 2.2 pounds):

For 10.5 per cent sacch. indication......	0.20 — 0.22 — 0.26 kg.
For 11.5 per cent sacch. indication......	0.25 — 0.28 — 0.30 kg.
For 12.5 per cent sacch. indication......	0.30 — 0.33 — 0.36 kg.
For 13.5 per cent sacch. indication......	0.32 — 0.36 — 0.40 kg.
For 14.5 per cent sacch. indication......	0.38 — 0.40 — 0.42 kg.
For 15.5 per cent sacch. indication......	0.40 — 0.45 — 0.50 kg.

For Bohemian beer the quantities of hops per hectoliter are as follows:

For 10.5 per cent sacch. indication......	0.30 — 0.35 — 0.40 kg.
For 11.5 per cent sacch. indication......	0.35 — 0.40 — 0.43 kg.
For 12.5 per cent sacch. indication......	0.42 — 0.46 — 0.50 kg.
For 13.5 per cent sacch. indication......	0.45 — 0.48 — 0.55 kg.

The boiling of the wort in the kettle, as well as the mashing in the mash pan, is as a rule still accomplished by means of direct firing, but steam heating is more and more taking its place in breweries of modern construction, since brewers have become convinced that the claims as to superior quality of beer from fire-boiled worts rested on prejudice. The amount of coal needed in steam heating compared to fire heating for the boiling of mashes and wort is about two to three. The amount of steam, according to Thausing, needed for this work, based on actual tests, varied from 36 to 54 kg. per hectoliter wort, which, based on an evaporating effect of 7.5 kg. would mean 4.8 to 7.2 kg. of coal per hectoliter, or about 13 to 20 pounds per American barrel, which figure is to be increased by 50 per cent in case of heating by direct fire.

In cooling the wort the same methods are employed and the same precautions are to be observed as in the corresponding operations in America (which see).

According to Prior, German worts contain in 100 parts of wort extract the following constituents, in approximate quantities:

Saccharose	2 to 6 per cent
Dextrose and levulose......	6 to 9 per cent
Maltose	52 to 63 per cent
Dextrins	18 to 26 per cent
Gums (taken from the amount of gum obtained by Lintner from a Munich beer), about	0.18 per cent
Nitrogenous substances (N × 6.25)..................	3.13 to 5.6 per cent
Mineral substances, about..	2 per cent
Free acids calculated as lactic acid	0.6 to 0.9 per cent

Aubry gives results of boiling hops with wort with regard to the amount of albuminoids eliminated. In 100 parts of wort extract he found the following amounts of nitrogen for unboiled wort and after boiling with hops (Wagner's Jahresberichte, 1892, p. 845):

		Total Nitrogen	Nitrogen not precipitable by phosphoro-tungstic acid.	Amido Nitrogen
Unhopped wort.......	A......	0.9263	0.5700	0.4053
	B......	0.7915	0.5458	0.3845
	C......	0.7653	0.5518	0.3967
Hopped wort.........	A......	0.8921	0.7114	0.5943
	B......	0.7576	0.4705	0.2964
	C......	0.7416	0.5106	0.3881

Bungener and Fries obtained amounts of different albuminoids before and after boiling, as follows:

	Before boiling.	After boiling.
Total nitrogen	0.650 per cent	0.540 per cent
Albumen nitrogen	0.163 per cent	0.057 per cent
Peptone nitrogen	0.125 per cent	0.100 per cent
Amide nitrogen	0.362 per cent	0.383 per cent

PRACTICE OF FERMENTATION IN GERMANY.

According to Thausing, the pitching temperature is chosen *lower for light* colored beers and higher for dark colored ones, *generally* between 4° and 6° R. (41° and 45.5° F.). The maximum

temperature of fermentation for Bohemian beers is 6° to 7° R (45.5° to 47.75° F.), for Vienna 7° to 7.5° R. (47.75° to 49° F.), for Bavarian 8° and 8.5° R. (50° to 51° F.). The amount of yeast used is the greater, the higher is the Balling indication of the wort, the smaller the fermenting vats, and the lower the temperature. The amount generally varies from one-third to three-fourths liter and should never be less than one-half liter for hectoliter of wort (about one pound per barrel).

The temperature of the beer after fermentation at the time when it is ripe for casking is 5° to 6° R. (43° to 45.5° F.). Sometimes it is cooled in the fermenting vats to 2° to 3° R. (36.5° to 38.75° F.). In the Munich breweries the beer is cooled on the way from the fermenting vat to the storage cellars, by means of pipe coolers to 3°, 2° or 1.5° R. (38.75°, 36.50° or 35° F.). The beer, ripe for casking, should contain a sufficient quantity of fermentable extract so that the secondary fermentation may proceed properly in the storage cellar. The opinion that high attenuated beers have a low degree of palate-fullness, and low attenuated beers a high degree thereof is untenable. If the beer in the fermenting cellar has high attenuation and shows sluggish after-fermentation a light bodied beer with poor foam-holding capacity is the result, whereas a high attenuation in the fermenting cellar combined with a proper secondary fermentation is unobjectionable. It is to be considered a favorable symptom if the difference between the attenuation of principal and secondary fermentation is a large one, and unfavorable if the difference is small. It will be unsatisfactory if this difference is only 2 to 5 per cent, satisfactory if 10 to 15 per cent, while differences of 20 per cent have been observed.

Some illustrations may be given:

1. A wort showing 10.5 per cent by the saccharometer reached 3.5 per cent by the saccharometer in the fermenting cellar, i. e., 66.6 apparent degree of attenuation (v = 66.6 per cent). After remaining in storage for six weeks the saccharometer still showed 3.2 per cent. The apparent degree of fermentation of the beer is calculated at 69.5 per cent (v' = 69.5 per cent). The difference between fermentation in fermenting and storage cellar (v' — v) is 2.9 per cent. The beer will turn out unsatisfactory.

2. A wort showing 13.5 per cent by the saccharometer is fermented in the fermenting cellar to 5.5 per cent (v = 59.2 pe

cent); in the storage cellar after four months to 4 per cent by the saccharometer ($v' = 70$ per cent). $v' - v = 10.8$ per cent. The fermentation is normal.

3. A wort is fermented in the fermenting cellar from 10.5 per cent by the saccharometer to 3.5 per cent, and in the storage cellar to 2.5 per cent by the saccharometer. $v = 66.6$ per cent. $v' = 76.2$ per cent; $v' - v = 9.6$ per cent. Notwithstanding the high apparent attenuation in the fermenting cellar the beer may be faultless.

The degree of attenuation that is desirable is different for different types of beer. For Bavarian beers an apparent degree of fermentation of 50 per cent is sufficient, whereas for Vienna and Bohemian beers 55 to 60 per cent is desired. Beers with low original extract should not attenuate so highly as beers with a high original extract.

CHIP AND STORAGE CELLAR.

Bohemian and Wiener lager beer is treated quite similarly in storage. Both are run "lauter" from fermenter, not "green;" storage temperature should be low, after-fermentation slow. The 12 per cent Bohemian lager beer is stored three to four months, the Wiener 13 per cent lager beers, about four to five months; neither is kräusened; the Bohemian is bunged for a long period, the Wiener often is not bunged at all.

Wiener "Abzug" beer, for which cold storage is essential, is six to eight weeks old, and is racked after a short bunging period. The Bohemian "Jungbier" is usually kräusened when racked into the trade packages and must consequently be allowed to settle before tapping.

Bavarian beer is not aged as much as the others as this would interfere with the sweet taste and palate-fulness. Bavarian beer is brought on the market after bunging about eight to fourteen days, about four to ten weeks old, the stronger beers being stored longer.

In piping beer the casks can never be filled to the bung-hole, owing to the foam. Hence, they must be filled up the following day. Sooner or later a white foam appears at the bung-hole, which proves an active secondary fermentation. The greener the beer was racked into cask, the more it contains of readily fermentable extract, and the warmer the beer and the storage cellar are kept, the bigger will be the hood of foam, and the after

fermentation may be so vigorous that beer is ejected from the bung-hole and runs down over the cask. This ought not to happen. In order to avoid loss of beer and for the sake of cleanliness, vessels are placed on the bung-holes to receive the foam and beer that is forced out, which is always very bitter. This is used for filling up casks or, properly treated, can be put on the market. The same object can be attained by not filling up the casks to the bung-hole until the intensity of secondary fermentation has somewhat abated. It is always advisable to let the foam work out of the bung-hole.

If no hood of foam rises from the bung-hole, notwithstanding the casks are full, or if it disappears very soon after rising, the beer being "dead" in the cask, it is a sign of deficient secondary fermentation which is always bad. The causes may be faulty malt, either overgrown or undergrown or spoiled in kiln, yielding a deficiency of fermentable extract in the beer; more rarely it may be due to casking the beer while too "lauter" (clear). The brewer should always watch the secondary fermentation closely.

The hood of foam contracts and takes on a deeper color, finally disappearing entirely, which is always the case with a sound beer if the cask was not full. The composition of the extract, the strength of the beer and the temperature of the cellar cause the foaming to stop sooner or later. What the brewer wants is that the hood remain for rather a long time without any violent working out. It affords a symptom for judging the progress of the secondary fermentation. After the hood has disappeared, the cask is filled up once more. For beers that are used young, stored cold, and properly prepared so as to be of normal composition, it ought to be enough to fill up once, as the secondary fermentation lasts a long time. Lager beers are generally filled up two or three times and when they have stopped throwing up foam, the bung-hole is loosely covered with the wooden bung.

CLARIFYING CHIPS.

While in storage, a sound beer becomes clearer by degrees, the particles making it turbid, as yeast and other suspended matters, especially albuminoids, settling on the bottom. In order to hasten clarification and make it perfect, clarifying chips are put into the beer where filters are not used.

These chips are made of hazel or white beechwood. The woo is cut so as to secure straight chips about 16 to 18 inches lo

1.5 to 2 inches wide, and $\frac{1}{16}$ to $\frac{1}{10}$ inch thick. They should be smooth and without cracks. Before using them they are thoroughly boiled in a special tub, changing the water repeatedly, steam that is pure and without oil or other impurities being commonly used, whereupon they are rinsed in cold water. They are wet when put into the storage cask, being inserted either into the empty cask through the manhole, which is simple and quick, or being added through the bunghole after the cask has been filled with beer. The beer is run on the chips if it is to be marketed soon, whereas it is preferable to insert the chips through the bunghole if the beer is to remain on storage for some time. They can be put in two to four weeks before racking for shipment, in the latter case. As to the number of chips for a cask a little experience will speedily give the requisite information. The more quickly the beer is to be clarified and the more stubborn it is of clarification the more chips should be used. As a rule one kilogram of wet chips is enough for one hectoliter of beer, which is equal to about half a kilogram of dry chips. Care should be taken to prevent chips lying in front of the tap-hole, which might cause trouble in racking. This is more likely to happen where the beer is run on the chips and for that reason experienced brewers generally prefer to put in the chips through the bung-hole or else remove the chips from the tap-hole after the cask has been filled.

"KRAEUSENING."

Occasionally the practice is met with of pumping beer intended for local consumption, from the storage cask to smaller casks, often on chips, and to "kräusen" it strongly at the same time, whereupon after it has become clear, it is bunged and racked, or, in small breweries, drawn directly for immediate consumption. It is believed to acquire particular brilliancy and life by this treatment.

Lager beers, and often young beers, are generally racked from the storage casks without "Kräusen" and quite clear. They are called "Abzugbier" in Austria. In Bohemia more especially, the practice prevails of adding some fermenting wort, in the low "*Kräusen*" stage, to clear young beer when racking into trade casks, particularly in the cold season. This wort is called "Kräusen" for short. The amount of "Kräusen" to be added should be the greater, the less active is the yeast, the older and more at-

tenuated the beer, the more foam is desired, the warmer the storage cellar in the brewery and the colder the bar-room in which it is to be kept while being consumed. The amount of "Kräusen" should, therefore, be governed by the condition of the beer and yeast, and the season. If too much is added, there will be danger of the beer being turbid when tapped and perhaps not becoming clear again at all. A small amount of "Kräusen" is half a liter per hectoliter, a large amount is 5 to 6 liters. As a rule, 2 to 4 liters per hectoliter is enough. The amounts must be determined empirically in each brewery and varied to meet the requirements.

"Kräusen" should always be taken from normally fermenting worts.

"Kräusened" beer, before being drawn, should lie still in the place of consumption for some time, from one to eight weeks, according to the temperature of the place. It should also remain lying still while being drawn. Only in rare cases does the practice survive of the dispenser of the beer opening the cask, filling it up until it is clear, and bunging it once more. If this is done, plenty of "Kräusen" should be given, as much as 10 liters per hectoliter or still more.

"Kräusening" serves to revive active fermentation in the beer. It is made to foam strongly and the large amounts of carbonic acid developed imparts a sharp taste and the foam becomes firm. It enables even beers that have been stored warm and are not suitable for consumption, as "Abzug" beers, to be sold in good condition. This affords a reason why breweries which put out "kräusened" beer need not be so particular about keeping their cellars cold. The Bohemian breweries sell their young beer all through the year almost altogether with "Kräusen," only lager beer being marketed without "Kräusen." It is the practice at Pilsen to allow the beer after being racked into trade casks with "Kräusen," to lie in the brewery for several days and undergo another fermentation, filling them up again just before they leave the brewery. The beer thereby becomes ready for consumption in the dispenser's room in a shorter time, requiring less time of storage on that account, furthermore, being stored in a cold cellar will foam better, the foam will be more solid and lasting, and the beer taste more prickly, all of which are virtues that distinguish good Bohemian beer. Another advantag

of "Kräusening" is that the fermenting beer in the trade cask is less sensitive to severe cold and also suffers less from heat. This is important in shipments to long distances, and explains why it is customary in Bohemia to add a small amount of "Kräusen" (one-half to one liter per hectoliter) even to lager beers which are intended for long distance shipments (export beers).

Beers that have been "kräusened" can be sold younger than "Abzug" beers, and need not be quite clear when leaving the brewery, since they remain in storage at the public-house where they become clear, provided the beer was good to begin with, the "Kräusen" is strong and the beer properly treated. This accounts for Bohemian breweries getting along with small storage capacity.

BUNGING.

The bunging period differs widely for one type of beer. General rules cannot be given. In Munich the summer beers are commonly bunged for about two weeks, the younger and weaker winter beers six to eight days. Vienna "Abzug" beers are usually bunged one or two weeks, lager beers either not at all or not to exceed two weeks. Bohemian lager beers are generally bunged for a long time, viz., up to four weeks and over, particularly if the storage cellars are moderately cold and the beers old. The pale Bohemian beer which is generally more highly fermented requires and stands longer bunging. The practical brewer will readily see if a beer has been bunged enough by drawing a sample through the try-cock. When the beer is agitated in the sample glass, numerous tiny bubbles of carbonic acid gas should rise in it slowly. It is a bad sign if the carbonic acid liberated by the agitation escapes quickly.

In draught (Abzug) and lager beers that are to be racked clear it is customary, in order to obtain the necessary life, to bung the casks tightly, thereby preventing the escape of carbonic acid gas and creating a pressure in the same.

The influence of temperature and bunging on the carbonic acid content of beer is shown by Langer and Schultze. The amount of carbonic acid in worts of 10 per cent B., in which 57 per cent of the extract was apparently fermented in the principal fermentation, was:

			Decrease of carbonic acid content per 1° C.
At 0.4°	C. =	0.332 per cent =	0.010 per cent
At 1.6°	C. =	0.326 per cent =	0.010 per cent
At 2.8°	C. =	0.311 per cent =	0.008 per cent
At 4.0°	C. =	0.297 per cent =	0.012 per cent
At 4.7°	C. =	0.297 per cent =	0.017 per cent
		Average =	0.012 per cent

It may be said that within the range of temperature from 0° to 5° C., the carbonic acid content of a Vienna "Abzug" beer, with equal pressure, rises or falls by about 0.01 per cent, according as its temperature rises or falls by 1° C.

The carbonic acid content of this Vienna "Abzug" beer when bunged for five and four days, respectively, showed an average increase for three tests of 0.046 per cent, i. e., 100 g. beer after bunging contains 0.046 g. carbonic acid more than before bunging, or 100 c.c. of beer by bunging takes up an additional 23.8 c.c. of carbonic acid. For 36 hectoliters of beer this amounts to nearly 9 hectoliters of carbonic acid gas more absorbed by bunging.

To increase the carbonic acid content of beer 0.01 per cent, an average excess of pressure of 31.3 mm. mercury column at 0° C. was required. When bunging was over, the tension within the cask averaged no more than 0.19 atmospheres.

The largest amount of carbonic acid that could be forced into this "Abzug" beer by the lowest cooling and moderate bunging at the same time was 0.390 per cent. The beer was excellent.

With 0.320 per cent of carbonic acid the "Abzug" beer of a brewery in Vienna was only medium good as to life and prickliness, but if the carbonic acid content fell below 0.320 per cent, the consumers began to complain.

SPECIAL GERMAN BEERS.

Besides the recognized types, like the *Bohemian, Vienna* and *Bavarian* beers, of each of which there are brewed two varieties, the *Schenk* or *Winter Beer* and the *Lager* or *Summer Beer* (see above), there are beers brewed for special purposes of each type like *Bohemian Export, Vienna Export* or *Bavarian Export*, or *beers brewed for* special occasions like Bock.

Export and *Bock* differ from the Schenk and lager in that they are brewed stronger and contain more alcohol. Thus the percentage of alcohol and extract found, as the result of the analyses of a large number of beers, was on the average:

	Alcohol.	Extract.
Schenk or Winter Beer..............	3.36	5.34
Lager or Summer Beer..............	3.93	5.79
Export Beer	4.40	6.38
Bock, Doppelt or Märzen.............	4.69	7.21

Beers are brewed in certain localities which have achieved a reputation far beyond the confines of their homes and which have certain peculiarities that distinguish them from the ordinary type. Such are:

Kulmbacher.—A very dark beer with the Bavarian characteristics especially accentuated, brewed along the lines of a Bavarian lager, from a very strong, original Balling of wort of about 18 to 19 per cent.

For Braunschweiger Mumme, Broyhan, Weissbeer, Adam beer and other special German beers, see "German Top-Fermentation Beers."

TOP FERMENTATION BEERS.

IN THE UNITED KINGDOM, AMERICA AND GERMANY.

While on the continent of Europe the lager or bottom-fermented beers have rapidly displaced the old-time top-fermented beers, excepting Weissbeer, they have been unable to gain much headway in the United Kingdom, where top-fermented beers, as ale and stouts, still hold undisputed sway. The same is true of Canada, and other English possessions, where lager beer breweries are still unknown in many localities, while in the United States there has been a decided revival of interest in ales especially.

ENGLISH TOP-FERMENTATION BEERS.

The beers brewed in the United Kingdom and its possessions show similar characteristic differences in their properties as the German beers. They are called "ale," "porter" and "stout."

Mild beers, whether ale, porter or stout, are called such as undergo no secondary fermentation, but are marketed about seven days after the principal fermentation is finished.

Stock beers, or old beers, whether ale or sout, are such as have undergone a secondary fermentation and are stored about two months or more before marketing.

The mild beers are distinguished from the stock beers by a more sweetish (mild) taste, containing more unfermented maltodextrin and less acid, the old beers, on the other hand, becoming more alcoholic and tart. There is, therefore, much difference in the properties of mild beers and old or stock beers.

Mild ales are usually brewed of a darker color than old ales, with less original gravity and less hops.

Old or stock ales have a pale to amber color, quite bitter tast
more or less tart taste, strong hop flavor, and though brewed w

a high percentage of extract, have less extract left, but contain more alcohol than stout, which is mainly due to the practice of dry-hopping ales, which results in breaking down the malto-dextrins more effectually than is the case with stout, which is not dry-hopped.

Stouts are quite dark, almost black, have a pronounced malt-caramel taste and aroma, a sweetish taste if mild, and a more or less tart taste, according to age and circumstances. They are brewed stronger than ales.

Porter is brewed less strong than the old beers. It stands in a similar relation to stout as does a mild ale to a stock ale.

BREWING MATERIALS IN ENGLAND.

The materials used in England, besides malt, hops and water, are usually sugars of different kinds. Such are caramel (produced from glucose) for black beers, invert sugar and glucose for mild and stock ales, while of late years, rice, maize and wheat are gaining in favor. The English drinking public now prefer beers of low gravity to the stock beers, and since they should contain only a moderate amount of alcohol, but sufficient extract to be full to the palate, sugars should be used for these beers, containing the requisite amount of unfermentable extract.

Malt.—Most brewers use some foreign barley malt, together with that produced from domestic grain, on account of the better clarification of beer and better drainage of wort, while some brewers use California barley malt entirely, the beer from which keeps better in hot weather (Thatcher Brewing and Malting, 1898, page 20). Foreign grain, besides, does not develop so much acidity and mold during germination.

Usually pale malt is employed in the production of all the beers, together with some coloring material, preferably caramel, brown malt, amber malt or roasted corn for dark ales, porter and stout. Sometimes black beers and mild ales receive an addition of caramel solution in the fermenting vessel just prior to the close of the principal fermentation. For dark beers higher kiln-dried malts are preferred by many brewers.

As to the requirements the malt is to meet and the production of English malt, see "Malting in England."

Hops.—With regard to hops, the English brewer favors the employment of foreign qualities of hops to blend with the domestic article, the proportion frequently rising to 50 per cent.

The English hops are distinguished for their delicacy of flavor, especially the East Kent goldings, and these are eagerly sought for flavoring choice pale ales in dry hopping.

The relative quantities of hops and of other materials to be used in brewing the different beers, according to the gravity of wort and other requirements, may be gathered from the subjoined table:

	Lbs. Hops in Kettle, Per Quarter Malt (336 Lbs.)	Gravity Long.	Hops in Kettle Per American Barrel.	Balling of Wort.
	Lbs		Lbs.	
London pale bitter ale....	8 10	20-21	1½-2	14
Burton mild ale............	7-8	19-21	1¼-1½	14
London four ale (mild)....	4-7	19-21	¾-1¼	13-14
Burton strong ale..........	10 14	23-25	2-3	16-17
Burton pale ale............	12-15	23-25	2½-3	16-17
Burton export ale....	18-20	25-27	3½-4	17-18
Porter......................	4-8	18-22	1-1½	13-15
Single stout................	8-10	23-27	1½-2	16-18
Double stout...............	10-12	27-30	2-2½	18 20
Imperial stout.............	14-15	30-40	2½-3	20-25
Russian export............	16	above 40.	3¼	above 25

Water.—The water used in brewing is given much attention in England (see "English Brewing Waters" in chapter on "Brewing Materials").

BREWING SYSTEMS.

Mashing operations are carried out according to the infusion system, although semi-decoction, or limited decoction, is employed in some breweries, especially where unmalted cereals are employed.

The mash for the production of the various beers is varied somewhat according to the materials used and the type of beer to be produced. For ales brewed from pale malt, higher initial temperatures should be taken than for black beers, or stout, where high kiln-dried malt is employed, and where a high degree of stability is required, like Dublin stout; whereas for London stout brewed for rapid consumption, moderate initial temperatures may be used to advantage.

The amount of malt used to mix with the water is about 125 *pounds per American* barrel (2 English barrels per quarter c *336 pounds).*

In all cases water of a comparatively high temperature (striking temperature) is run into the foremasher or outside masher, where it is well mixed with the malt, then falling into the mash-tun, which contains warm water enough to cover the false bottom. The rakes are run to get even initial or primary temperatures, the mash is allowed to stand a short time, when the temperature is raised by an underflow of water of about 180° under the false bottom or through an underlet, to the end temperature, which is generally but little above the initial temperature. Here the mash is allowed to stand or rest for about one and one-half to two hours, after which the wort is drained completely, and sparging is undertaken. The temperature of the first sparging water is usually taken higher, about 170°, for a few barrels, as the grains have cooled somewhat; then 160° to 165° is taken, which will bring the temperature of the mash to about 160°, which is the permissible limit. After reaching this temperature the remainder of the sparging water should be run on so as to have the mash gradually recede to 152°, which is approximately the tap heat that should be maintained through sparging operations.

Temperatures may be taken as follows for different types of beer:

Pale or Stock Ale.—Initial temperature, 151° to 152°; stand 15 to 30 minutes; raise temperature by underflow to 153°; stand one and one-half to two hours, and tap.

Irish Stout from high kiln-dried malt. Initial temperature, 143° to 145°; let stand, 15 minutes; and raise heat 152° by underflow of 180°.

London Stout from high kiln-dried malt. Initial temperature, 148° to 150°; let stand, 15 minutes, and raise to 152°, with underflow of 180°.

Limited Decoction.—This process seeks to combine the German decoction process with the English infusion method. The mash is carried out as usual, the mash-tun being, however, provided with a steam coil. After running off the first wort to the amount of half a barrel per quarter (1 U. S. barrel to 500 pounds of malt) into a separate vessel until required, steam is turned on, and the temperature of the mash raised to 212° F. (80° R.) where it is kept for about 15 minutes, when the temperature is reduced to about 160° F. (57° R.) by sparging with cold water

while stirring. Then, the wort which was held in reserve is returned, and the temperature brought to 160° F. (57° R.). The mash is left to rest for 20 to 30 minutes, and taps are set, and operations continued as usual.

When unmalted cereals in the form of grits are employed they may be treated according to methods familiar to American brewers. In England, it would seem, the maize cannot be sufficiently gelatinized by employing the methods there in vogue, the unmalted cereals not being subjected to high enough temperatures, nor sufficiently long. The raw cereal mash when considered properly gelatinized, is cooled to the usual striking temperatures of the water, and the malt is run in to get the ordinary initial temperature, and operations are continued as usual.

Boiling the Wort.—While running into the copper the wort is held at a sufficiently high temperature to destroy the diastase, and some brewers boil while the kettle is filling, others bring to ebullition as soon as filled. Hops are sometimes added as soon as the heating surface is covered, but it seems to be becoming the more usual practice to add the hops when boiling sets in, adding all the hops at once in the production of black beers and mild ales, while in the production of stock or pale ales a large proportion (⅔ to ¾) is added when boiling sets in, the remainder about 15 to 20 minutes before turning out, the wort being left gently to simmer after the addition of the second portion in order not to lose too much flavor.

Some brewers boil only one hour, others two and more, but two hours' boiling seems to be becoming the more general custom.

In many breweries the copper has not sufficient capacity to hold the entire brew. The wort is then boiled "at twice," or in "two lengths," or even at three times or in three lengths. *Sparging* is kept up under these circumstances until the kettle is full, the taps are then closed and the wort is allowed to "stand on" until the first length is finished, or the second length is collected in an "underback," where it is kept hot until needed.

From the copper the wort is "turned out" into the hop-back, *where it rests for* about 20 minutes, and is pumped to the sur- *face cooler,* where it lies until the temperature is reduced *130° to 140°.* It is then passed over or through a pipe coo

to reduce the temperature to 58° to 60° F. (12° to 13° R.), and is then ready to receive its addition of yeast.

TOP-FERMENTATION APPLIANCES AND OPERATIONS.

The essential difference between top-fermentation and bottom-fermentation is in the behavior of the yeast, which rises to the top during top-fermentation, where it is either removed by suitable implements, by a process called "skimming," or is allowed to work out of an aperture at the top of the fermenting vessel, by a process called "cleansing." If the cleansing takes place in casks, the yeast working out through "swan necks" into a common trough, it is called "Burton union system;" if through openings (lips) in the top and edge of upright tanks, the tanks themselves being so placed as to form a trough for the yeast, it is called "Ponto system." Then there is a combination of the skimming and the cleansing systems in the "stone square system," the yeast working out through the top of a closed stone square, from where it is removed by skimming.

FERMENTING VESSELS.

These are now chiefly constructed of wood (oak or fir and also American cedar of late). Stone and slate have not given satisfaction, although still extensively used in some parts.

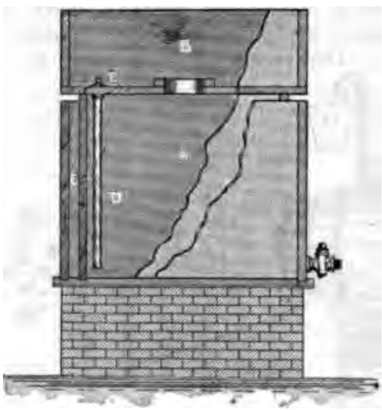
The vats are made either round or square and are called "rounds" or "squares," respectively. Rounds are usually made of oak staves, held together by iron hoops; squares, of planks about two inches thick, bolted together with iron bolts, generally made of fir or cedar.

The vessels are not coated with varnish or pitch, as is the case in lager beer breweries, as the alcohol in some ales reaches such a high percentage as to soften pitch or shellac. Oak vessels are prepared by filling them with boiling hot water a number of times, while fir containing much resin must receive special treatment. Southby recommends to fill such vessels first with boiling water, which is run off the next day. Then the sides are scrubbed with a mixture of 2½ pounds of chloride of lime per gallon of water. After 24 hours the vat is washed out with a mixture of one part of hydrochloric acid and four parts of water. Then it is washed out several times with boiling water and finally scrubbed out with an ordinary solution of bisulphite of lime to remove all traces of chlorine

American cedar needs no special preparation, but may be used after being scrubbed out.

"Stone squares" should be constructed of large slabs of hard, impervious stone, or of slate, which retains a smoother surface during wear. The description and sketch here given are taken from Sykes, the Principles and Practice of Brewing, 1897, p. 445.

The stone square has a jacket, C, also built of stone slabs, leaving a space of about two inches, which is filled with water for the purpose of attemperating the beer. The square proper, A, is covered over with another slab having a circular aperture, the "manhole," of 18 inches' diameter, which is surrounded with a stone ring some 5 or 6 inches high, on which fits



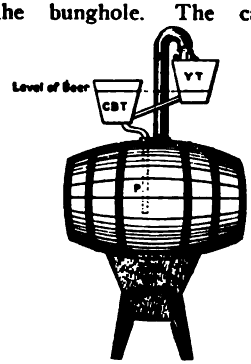
Yorkshire Stone Square.

a stone lid provided with a handle. In one of the corners of the covering slab is another opening situated a few inches from each of the sides and about three inches in diameter, provided with a brass valve, E, to which a chain is attached. From the under side of the valve a tube, D, extends to within a few inches of the bottom of the square; this is technically known as the "organ pipe." Upon the upper side of the covering slab is placed the yeast trough, B, constructed of four stone slabs. It has the same superficial area as the square, and a depth of from 24 to 30 inches. A pump is one of the necessary adjuncts of a stone square. Its diameter is about th inches and stroke six inches. The stone square must be

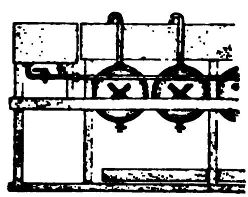
fully cemented in all its joints and should be inspected from time to time, as any defects in the jointing are certain to make trouble.

Instead of the water-jacket an ordinary attemperator may be used inside. Slate cannot be cleansed by boiling water, as it would be likely to crack or split. Neither can bisulphite of lime be applied, as it would attack the slate. Neutral sulphite of lime is therefore used to whitewash the inside of the square for antiseptic purposes, while coatings or deposits on the surface are removed by caustic potash or soda solutions.

Loose Pieces.—Where the cleansing method is employed, brewers often run the beer from the square or round into casks or puncheons holding about four barrels. They are placed on troughs in which the yeast is collected that escapes from the bunghole. The casks are inclined to one side so



Cleansing in Loose Pieces—From A Handy Book for Brewers, by H. E. Wright.



Burton Union - From Sykes, Principles and Practice of Brewing.

that the yeast runs down one side only. Sometimes conical tinned pipes are inserted into the bunghole, called "swan necks," through which the yeast works out into the trough. The casks must be kept "topped up" continually—every two hours during the first 24—using for this purpose first the clear trough beer, and when this is used up, bright beer from a previous brewing.

The loose-piece swan necks are often so arranged that the *same trough* serves both as yeast receiver and feed trough (for *topping up*). But according to Wright it is much better to have *them quite* distinct, the only necessary precaution being to have *the bottom* of the feed trough some inches above the bun

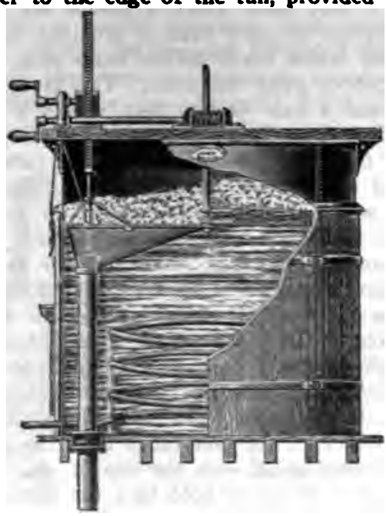
holes, so that the beer level may be well up the swan neck pipe (see sketch, page 800).

Burton Unions.—In this system the principle is the same as with the "loose pieces," but there are many differences in detail. The casks holding about four barrels are permanently mounted on tall wooden stands, to which they are slung by means of two axles, one attached to each head. These work in bearings and permit the cask to be rotated on its axis, the front trunnion having a square head upon which a handle fits for this purpose. The bunghole of each cask is provided with a conical brass socket, into which fits a hollow brass plug, carrying the swan neck to convey away the yeast. This is carried up vertically a foot and a half or two feet, makes a turn of half a circle and curves over into a long wooden trough which extends between the rows of adjacent casks, called the yeast trough. At one end of this another vessel is fixed, called the "feed trough," which has a capacity of five or six barrels. A tap is fixed into the bottom of this, from which a pipe of about two inches diameter proceeds, extending in front of each row of unions and giving off a short branch to each cask, with which it can be connected by means of a union joint to a tap permanently fixed in the head of the cask. Another cock is fixed in each cask exactly opposite the bunghole, and is provided with a short tube, which projects some little distance inside the cask, and which can be raised or lowered by means of a screw. This serves for the removal of the fermented beer, and as the tube communicating with the tap is some little height above the bottom, it serves to hold back the bottoms. When a set of unions are cleansed, the swan necks are first removed and the feed-pipe communications unscrewed; the handle is then attached to each cask in turn, boiling water poured into it and the cask rotated on its axis. This is an objectionable feature in the system, for the introduction of large quantities of hot water into the fermenting room necessarily raises its temperature. (Sykes, the Principles and Practice of Brewing, 1897, p. 448.)

Attemperators are made either fixed or movable. The fixed are *made of tinned* copper pipe, oval in section, and the whole *forms a continuous* coil circling the tun about three times.

Movable attemperators are suspended with chains and bala *weights.*

Arrangements for Skimming.—Small rounds or squares are usually skimmed by hand. In large rounds either a "parachute" or "skimming" board is used. The parachute is a funnel connected with a pipe penetrating the bottom of the tun. For rounds, the skimming board is made to revolve around a central rod, and is capable of being raised and lowered, as well as rotated, from the outside of the tun. It pushes the yeast before it into a trough, which extends (instead of a parachute) from the center to the edge of the tun, provided like the para-



Fermenting Round with Parachute—From Sykes, Principles and Practice of Brewing.

chute with a down pipe through the bottom of the tun. (Wright, a Handy Book for Brewers, 1897, p. 498.)

In the squares the trough extends along one of the sides.

A Rotary Pump is used for rousing and is so constructed that it permits of the raising of the continuous stream of wort, or pumping air into the fermenting wort.

Another contrivance for rousing and aerating at the same time consists of a small cask of about three gallons' capacity, with both its ends removed and having a number of holes bored through its sides. It is weighted with lead so as to sink readily, and suspended by a rope passing over a pulley. T

cask is let down into the fermenting wort and pulled suddenly to a short distance above its surface; by repeating this several times, a very efficient rousing and aeration is secured. (Sykes, the Principles and Practice of Brewing, 1897, p. 451.)

TOP-FERMENTATION OPERATIONS.

The amount of yeast to be added is dependent upon the system of fermentation used, the fermentation temperatures, gravity of worts fermented, materials and temperatures used to produce wort, quality and consistency of barm employed, and amount of aeration.

With the Yorkshire stone square system, a slow type of yeast is employed at the rate of only ¾ to 1¼ pounds per barrel.

The following table for the other systems may be found useful (Thatcher, Brewing and Malting Practically Considered, 1898, page 86):

AMOUNTS OF PITCHING YEAST REQUIRED FOR WORTS OF DIFFERENT GRAVITIES.

12 lb. worts	½ to 1 lb. per bbl. or	⅜ to ⅞ lb. per American bbl. of	8¼ Ball.
15 lb. worts	1 to 1¼ lb. per bbl. or	⅞ to 1 lb per American bbl. of	10½ Ball.
18 lb. worts	1¼ to 1¾ lb. per bbl. or	1 to 1½ lb. per American bbl. of	12¼ Ball.
21 lb. worts	1½ to 2 lb. per bbl. or	1¼ to 1⅝ lb. per American bbl. of	14¼ Ball.
24 lb. worts	1¾ to 2¼ lb. per bbl. or	1½ to 1⅞ lb. per American bbl. of	16¼ Ball.
28 lb. worts	2 to 2½ lb. per bbl. or	1¾ to 2 lb per American bbl. of	18¾ Ball.
30 lb. worts	3 to 3½ lb. per bbl. or	2 to 2½ lb. per American bbl of	20¼ Ball.
35 lb worts	3½ to 4½ lb. per bbl. or	2½ to 3 lb. per American bbl. of	23¼ Ball.

In many breweries the yeast is added to the whole of the wort after it has reached the fermenting tun. Sykes recommends first to run down a small portion of the wort at a temperature of from 65° to 75° F., and to mix the yeast with this. In this way a rapid and vigorous growth of yeast is secured from the onset, and the reproduction of any bacterial organisms, should these happen to be present, effectually held in check. The remainder of the wort is then run in at a slightly lower temperature than that which the whole bulk is to have when collected, so that at the finish the gyle may be at the proper heat. The wort, while being collected, is roused at frequent intervals in order that the yeast may be evenly diffused through it.

Where much rousing and aeration takes place the yeast will *multiply faster*, and less yeast is required for pitching (stone *square system*).

The best yeasts come from beers of medium gravity, not *heavily hopped.* In strong worts the yeast gradually bec

sluggish, and in heavily hopped wort its surface acquires a coating of hop-resin, which naturally interfers with the fulfilment of its proper functions (Sykes).

Fermentation Temperatures.—The weaker beers of about 18 to 20 pounds Long. (12½ to 14½ Balling) are started at about 58° to 60° F., and are allowed to rise to 66° to 70° F. Stronger beers are started from 56° to 58° F., and are allowed to go up to 75°.

Where the plant is provided with powerful attemperators the fermentation may be commenced at a higher temperature and confined within narrower limits, say between 62° and 65° F., with good results. Lower fermentation temperatures are said to give beers with finer flavor.

Appearance of the Heads of Yeast During Fermentation (according to Sykes).—Two or three hours after pitching small bubbles of carbonic acid begin to rise to the surface. In another two or three hours froth begins to form around the sides of the vessel, and this gradually extends over the whole surface and increases in volume, until what is termed the "cauliflower stage" is reached. This then gradually passes into the "rocky head stage." The heads go on steadily increasing for a time, and often attain a height of three and four feet above the surface of the wort. The more or less "frothy head" now commences to fall, and the "yeasty head" commences to form. This is in a constant state of motion from the continual formation and bursting of the large bubbles of gas. With the commencement of the formation of the yeasty head, what is known as the "skimming point" is reached, the normal time for this being about 48 hours from the time of pitching. The gravity of the wort will by this time, according to circumstances, have been reduced to from one-half to two-thirds of its original gravity. It is at this point that the separation of the yeast from the wort begins in the cleansing and skimming systems, and it is also the point at which the treatment of the beer on the different systems diverges.

Cleansing System.—The wort is pitched at 56° to 60° F., and when its gravity is reduced about one-half, and its temperature has risen to about 70°, which is generally reached in 36 to 40 hours after pitching, it is run into the cleansing casks, loose pieces, or Burton unions. The temperature is easily kept dow

in the small casks to 70° in winter. Where the casks have no attemperators the beer is run down at a somewhat lower temperature in summer. The casks must be kept continually full by feeding or topping up by hand, as otherwise the yeast is not completely ejected, some of it, sinking to the bottom, and the beer is likely to acquire a yeasty taste. (See also above under "Loose Pieces" and "Burton Unions.")

Skimming System (according to Sykes).—In this system the fermentation is started in the same way as in the cleansing system, but when the skimming point is reached, the wort, instead of being run off into cleansing casks, is well roused. As soon as the head begins to assume a distinct yeasty character it is skimmed off once in every six hours, or even oftener, by hand or special apparatus, and the wort which passes off with the yeast should be freed from the latter and returned to the vat. When the temperature of the fermenting wort has risen to about 59° F., the attemperator is started slowly, and the flow of water through it is so regulated that the heat is allowed to rise half a degree every three hours. When the temperature has reached 65° to 66° F. the attemperator is put into more vigorous action in order to prevent any further rise of temperature. As soon as the process of fermentation begins to slacken, the temperature is lowered till it reaches 60° F. Skimming is kept up till the wort is judged to be able to throw up just one more head of sufficient thickness to protect it from atmospherical contamination.

The right point to stop skimming is found by pushing a small portion of yeast on one side and examining the surface of the beer thus exposed. When this appears black and clear, denoting that there is scarcely any more yeast in suspension, skimming is stopped, and the head which subsequently forms is allowed to remain undisturbed.

Dropping System (according to Thatcher, Brewing and Malting, Practically Considered, 1898).—This system is so thoroughly suited for producing modern light gravity pale ales that its adoption will ultimately become general among the brewers of the United Kingdom. The beers after being fermented in rounds or squares, as usual, until the skimming point is nearly reached an the correct temperature attained, are then dropped into suita vessels, situated upon a lower floor. These dropping vessel generally squares or rounds, rather shallow, preferably

structed of slate, or wood, copper lined, the shallowness inducing expulsion of yeast by surface attraction, consequently clearer beers are attainable. Attemperators are fixed in both top and bottom vessels. After dropping, the beers are treated as upon the ordinary skimming system, removal of yeast, attemperation, etc.

By dropping the beer, the yeast is thoroughly aerated and thus stimulated to vigorous reproduction. The dirty head, containing hop-resins, bacteria and other foreign matters, is left in the top vessel, consequently only a fresh and clean supply of yeast rises in the dropping vessel.

Following is a typical fermentation of an 18 pound (12½ Balling) beer:

		F.	Pounds.	
Wednesday,	7 p. m.,	59	18.0,	added 1¼ pounds yeast per barrel.
Thursday,	7 a. m.,	59¾	17.3,	throwing off the blanket.
Thursday,	7 p. m.,	61	16.0,	rocky, alpine-looking head, dirt removed as it arose.
Friday,	7 a. m.,	64	14.0,	frothy head, attemperator on.
Friday,	7 p. m.,	69½	10.2,	run to dropping square.
Saturday,	7 a. m.,	70	7.5,	attemperated, skimming every three hours.
Saturday,	7 p. m.,	70½	5.0,	attemperator off, skimming every three hours.
Sunday,	7 a. m.,	69½	5.5,	last skim, afterward added priming solution.
Sunday,	7 p. m.,	67½	5.5,	settling, attemperating hard.
Monday,	7 a. m.,	62	5.5,	settling, attemperating hard.
Tuesday,	7 a. m.,	58½	5.5,	racked.

Yorkshire Stone Square System (according to Wright, A Handy Book for Brewers, 1897).—This system is not gaining in favor. The necessary number and costliness of the vessels are against it, also the difficulty of maintaining thorough cleanliness on account of the liability of the stone slabs to crack under the influence of boiling water.

The yeast is usually mixed with wort in the upper square (see above), and then allowed to run into the lower, which has been filled or nearly filled. Periodical rousing by means of a pump, the number of strokes given increasing with each repetition, is the cornerstone of this system. It begins between 20 and 30 hours after pitching, with the pump-rousing of the contents of the upper square, which has had some inches of wort left in it, now, however, allowed, by opening the valve, to flow into the lower square. Subsequent pumpings are from the lower square into the upper, whence the wort flows back into the lower again, through the open valve, these pumpings being continued at intervals, till the degree of attenuation is reached at which yeast begins to form. The yeast works out of the man-

from it flows back into the lower square, through the valve. The latter is left open till the fermentation has nearly reached its term, when it is closed for good, any excessive formation of yeast being afterward skimmed from the manhole. Owing to the enormous degree of aeration and the mechanical rousing which the fermenting worts undergo, the range of temperature can be very much restricted. It rarely exceeds 6° F., compared with the normal 9°, 10° or even 12° of ordinary systems.

Cleansing in Pontos.—This system is dropping into disuse altogether.

RACKING.

After the yeast-making has ceased, the beer is allowed to rest for 24 to 48 hours, so as to deposit the bulk of the yeast held in suspension, and as soon as it has become sufficiently settled it is run off either into the store or the trade casks, care being taken to avoid any agitation which would cause excessive frothing and the rise of yeast in the tun.

All casks must be thoroughly steamed before filling. After racking, the packages are bunged and brought to the cellar, the bungs are again removed that any excess of yeast may work out, and the packages are filled with clean, bright beer. The stock beers usually receive a porous spile or bung to give necessary vent.

DRY HOPPING.

Ales usually, and black beers sometimes, receive an addition of hops in the storage or trade cask, the quantity varying from one-quarter pound for mild ales to one pound per barrel for pale, bitter and stock ales. The kind of hops used for this purpose are Bavarian, California, Mid-Kent and Sussex (Thatcher). The beer, through dry hopping, acquires greater stability and hop flavor, while the tannic acid of the hops promotes clarification. The hops are introduced into the empty cask by means of a wide funnel, through which hops are pushed with a short wooden rod, care being taken that the hops are simply loosened and not broken into fragments (Sykes). Hops contain diastase, which degrades certain types of malto-dextrins, so that they become fermentable.

SECONDARY FERMENTATION.

Stock beers undergo a secondary or slow fermentation in th *storage or trade* cask. If this fermentation is unusually live

the beer is said to "fret" or "kick up." The secondary fermentation is carried out, not by the same yeast that fermented the sugar during the principal fermentation, but by other types, often wild yeast. The malto-dextrins of the beer supply the substance for this fermentation, being partly degraded by inversion enzymes contained in the yeasts and by the diastase introduced in dry hopping. Thus, beers that are dry-hopped ferment down lower in the cask than beers unhopped in cask, like most black beers. The fermentation of the sugars formed by the breaking down of the dextrins, keeps the beer charged with carbonic acid gas, and this condition is essential for checking the development of foreign ferments. Therefore, a sound secondary fermentation is of the greatest importance. Most English beers are sent out directly after racking, dry hopping and fining, and before secondary fermentation has set in, the demand for stock beers having diminished more and more in late years; or, the secondary fermentation is hastened by frequently rolling the casks for the purpose of keeping the yeast in suspension, and the beers are sent out after a storage of a few weeks.

Priming.—Often a solution of some kind of sugar is added to the beers, especially the black beers, in the cask, which process is called priming. The object is to impart sweetness or body, or to aid secondary fermentation and give "life" or what in England is termed "condition" or "briskness." In the former case glucose is added, while for briskness, priming with invert-sugar is recommended. The priming syrup prepared for this purpose should have the full strength permitted by the excise regulations, that is, a specific gravity of 1.150, or about 40 per cent Balling. Priming is also practiced where beers show abnormal turbidities, or cold water extract of malt may be prepared and added in cask to produce a more vigorous secondary fermentation.

Vatting.—In many breweries it is still customary to blend a young beer with an old one that shows acidity and proper flavor in a marked degree, in order to give the product the character of age. Especially is this done with stouts. The old beers are called vats, and as much as 25 per cent is blended at times with the young beer. "The first requisite," says Wright, "is that the vats should come into rapid blending condition, which implies a *high degree of* acidity, short of sourness, however, coupled with

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absolute brilliancy, results which are generally secured by fermenting beers of no remarkably high gravity at high temperatures, and supplementing this with rousing and aeration. If the ordinary English system be followed, vatting is perhaps the only way of getting that amalgamation of flavors which characterizes a perfect stout. Accordingly a blend of a vatted stout, having a gravity of 30 pounds (20 per cent Balling) or higher—the higher the better—with a sweet running porter of say 18 to 19 pounds gravity (12 to 13 per cent Balling) will certainly give far better results than a single stout brewed at 24 to 25 pounds gravity (16 to 17 per cent Balling), and sent out unblended."

Worting.—Stout and porter for immediate draught often, besides being blended with vatted stout, receive an addition of unfermented wort varying from half a gallon to a gallon and a half per barrel (Southby, Practical Brewing). Those stouts which are intended for bottling and export must not be worted.

Finings are added either before the beer is sent out, or by the customer in his cellar. About one pound of good isinglass is made up to about 10 gallons, according to processes familiar to the American brewer, the cold method of preparation being employed, and tartaric acid and sulphurous acid are usually used in cutting. About one to two pints is added to a cask (1½ U. S. barrel).

Beer Storage (according to Southby).—Beer may be stored either in the casks in which it is to be sent out, or in vats of larger or smaller size. In former days, vatting was almost universal, but since the great success of the Burton ale breweries, vatting has gone more and more out of vogue, and is now almost confined to the storage of the stronger class of black beers and some special varieties of strong ale. For stout, the vatting system seems alone capable of inducing those peculiar changes and the development of those ethers and flavors so much valued in the finest productions of the London and Dublin porter brewers.

When storing ale in casks, it is necessary to provide against the excessive development of carbonic acid. This is usually effected by the use of the porous spile.

These spiles are made from the wood of the American black oak, which is full of tubular cells running in the direction of the grain. They are made about an inch long and turned slightly conical. They are not pointed, but both ends are flat and cut

across the grain, thus allowing an egress for the carbonic acid as it is generated. As, however, they flatten the beer to some extent, they should be replaced by tight spiles a short time previous to the beer being sent out for consumption. When beer has been long stored, the tubes of the porous spiles become clogged with yeasty and extractive matters, so that after a certain time they cease to allow any gas to escape. Therefore, fresh porous spiles should replace the old ineffective ones where beers are stored for a very long time.

By storing beer in good cellars, in which a uniform temperature of about 54° F. is maintained, almost all risk of the beer becoming acid is avoided, provided it is well brewed and from good materials. There are, however, some inconveniences in this method of storage, for, if the cellars are very cool the beers stored in them are apt, when removed into a warmer atmosphere, to kick up, owing to their not having previously gone through that slow fermentation in cask which is sure to take place sooner or later in all stock beers. On the other hand, if the cellars are maintained at a somewhat higher temperature, the beers are apt to chill and become cloudy when removed in cold weather.

The fact is, that by coddling beers, while you certainly preserve them from disease, you are sure, at the same time, to render them tender and susceptible to every change of temperature. Burton beers, in former days, were exposed by day to the heat of the sun, and by night to the frost, and, by this treatment, they became so hardy that they retained their condition and brilliancy under the most adverse influences. In Burton the usual practice is (Southby, 1889) to stack up the casks in open yards, covering them up by means of hurdles wattled with straw. As the warm weather comes on, further protection becomes necessary, and the casks are either placed in the now vacant malt house, or the straw is frequently wetted during the day by sprinkling it with water.

Ales of sufficient strength, or pale ales in which a large proportion of hop has been used, can be stored in this rough manner with safety, but a great risk is run with the lighter class of ales unless they are stored in cool cellars.

BOTTLE BEERS.

According to Wright, ale for bottling should be allowed to *go through all* its cask changes, spontaneous brilliancy (un-

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aided by finings) at the end of them being the simplest criterion of ripeness for bottling.

The temperature of the bottling cellar should not exceed 55° F. (10° R.), and may well be lower, and a fair amount of ventilation, if it can be managed, with a uniform temperature is desirable. When bottled, however, a higher temperature is required to insure proper condition, say from 58° to 60° F. (11½° to 12½° R.); but note that too speedy maturity is not to be wished for, pointing, as it does, to faulty brewing or incomplete secondary fermentation.

Messrs. Bass & Co. used to issue the following instructions to their agents:

"The proper season for bottling pale ale commences in November and ends in June.

"Pale ale should not be bottled during the summer months, nor after hot weather has set in, even though the temperature should afterward become cool.

"The ale should be placed bung upward in a cool, ventilated store, about 50° to 55° F. temperature.

"If the ale should get into a brisk state of fermentation, a porous cane or porous oak spile should be inserted in the bung until the excessive fermentation has subsided, when a tight, close peg should be substituted.

"Ale should never be allowed to become flat.

"It should be bright and sparkling when bottled, but not fermenting. The bottles to be corked directly they are filled.

"In bottling, a tap with a tube reaching toward the bottom of the bottles should be used.

"When corked, the bottles to be piled standing upright and not lying on their sides.

"When the ale becomes ripe, a sediment will be deposited in the bottles. In uncorking be careful not to disturb it, but empty the contents of the bottle into a jug, keeping back the sediment."

A simple test for bottling fitness is to fill a clean bottle with the beer and keep it at a temperature of about 90° F. (26° R.) (see "Microscopical Laboratory") for about four days. If no deposit shows within this time, good results may be expected.

TURBIDITIES AND OTHER DISEASES.

Beer Turbidities.—These are brought about by much the same causes as those affecting lager beers under certain circumstances. Their treatment is much more difficult since the beers are stored

mainly in casks, and filtration cannot be resorted to. Recourse is, instead, had to the addition of finings. Beer turbidities may be caused by:

Weak Yeast.—If the yeast in the storage cask is the progeny of a weak yeast, it is apt to be light, settles slowly and rises upon the slightest provocation. Greatest attention must be given to the stock yeast to keep it in a condition of strength and purity. Yeasts from medium gravity worts give the best results, as those from very high gravities are apt to be overfed and sluggish, while low gravity worts may not satisfy the yeasts in point of nutrition. The precautions to be used in selection, general treatment, strengthening and purifying of the yeasts are much the same as for bottom-fermentation yeasts.

Wild Yeast.—The types of yeast causing cloudy frets are *Sacch. pastorianus III* and *Sacch. ellipsoideus*, both of which, according to Matthews and Lott, may cause a distinctly unpleasant smell and flavor or stench, but beers which have gone through such frets may, if otherwise sound, become quite palatable.

Another wild yeast type found to cause beer turbidity is *Sacch. exiguus*, a light, elongated yeast. In this case the turbidity, according to Matthews and Lott, is prolonged and accompanied by marked flatness, which is probably not unconnected with its inability to ferment maltose.

Bacteria Turbidities.—The bacteria most frequently met with in beers, and those which cause undue turbidities besides souring and, in some cases, stench and ropiness, are sarcina, lactic forms, *saccharobacillus pastorianus* (these three produce souring). Butyric forms may produce a disgusting smell, and are sometimes found in returned ales. (Matthews and Lott. The Microscope in the Brewery and Laboratory, 1899). *Mycoderma aceti* or *bacterium aceti*, often found in returned ales, causes marked acidity even when ales are only moderately infected.

Ropiness.—This is a condition of the beer of being highly viscous so that it flows like thick oil or even hangs in strings when poured. It seems to be due to organisms, but the question is still in doubt. Slack malt, light hopping and imperfect cleansing seem to favor viscous fermentation. Van Laer succeeded in causing ropiness in sugar solution by infection with two kinds of *bacillus*, which he calls *bacillus viscosus I* and *bacillus viscosus II*, and it is known that an organism called Leuconostoc mesen-

teroides has the power of converting large quantities of the juice of the sugar beet into a viscous, syrupy mass. *Pediococcus viscosus* has been found to cause ropiness in German Weissbeer.

Albuminoid and so-called hop-resin turbidities seem as yet to be little understood in England. As to albuminoids, it would seem that this form of turbidity admits of a ready explanation, as the high initial mashing temperatures employed in England favor the formation of proteids of a kind that do not readily precipitate (see "Peptase and Albumen") and make their appearance when the beer is cooled to lower temperatures. (See also "Principles of Brewing.") In America much attention is given to avoiding this form of turbidity, since the lager beers are stored and consumed at much lower temperatures than ales or stouts, and relatively small quantities of albuminoids, or proteids, as we call this objectionable class of albuminoids, make their presence known, on account of their almost absolute insolubility at temperatures near freezing point.

Starchy Turbidity: (See "American Lager Beers.")

Beer Sickness Due to Dry Hopping.—Sometimes fermentation is too quickly accelerated in the cask by the addition of hops and a permanent "fret" ensues, while at the same time an unpleasant flavor becomes noticeable. This may be caused by organisms introduced with the hops.

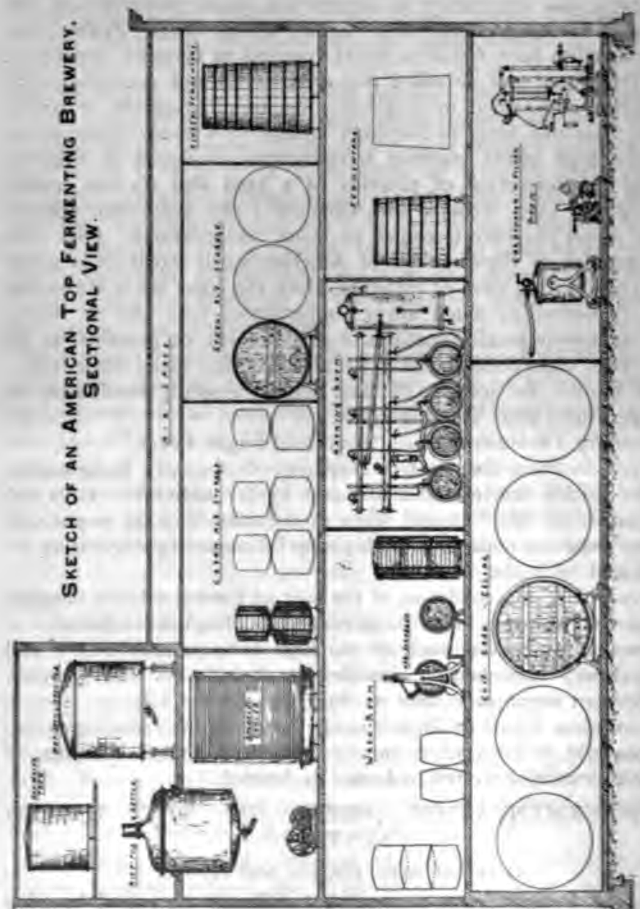
Yeast Bite is a condition of the beer of having a bitter clinging disagreeable taste. This is attributed by English authorities to a number of causes, such as too high temperatures at the end of primary fermentation, insufficient aeration, or the presence of foreign organisms, such as Sacch. pastorianus I.

Bisulphite Smell or Stench is attributed to the reducing action of bacteria or even yeast on the sulphurous acid it contains, in which case sulphuretted hydrogen is formed.

TOP-FERMENTATION BEERS IN THE UNITED STATES.

AMERICAN ALES, PORTERS AND STOUTS.

In the United States a somewhat different system of brewing has developed in the production of top-fermentation beers, from those employed in England. While the American stock beers are patterned after the English stock ales and stout, *cream, lively,* or *present use ale* takes the place of the English mild ales, and more recently the American ale brewers are equipping their plants



(The publishers are indebted for this sketch to Mr. C. Haefner. It will be seen that proportions have been ignored for reasons of space, since if the smaller vessels and implements had been drawn to the same scale as the big ones, they would appear too minute. The arrangement is the principal thing intended to be shown.)

with refrigerating machines to brew a beer—*brilliant or sparkling ale*—that combines the properties of lager beer and ale, i. e., a sparkling, brilliant beer with an ale taste and aroma. Since these ales have been put on the market, top-fermented beers have gained some of the ground which they had lost in competition with lager beers.

In the main, the equipment of a modern American ale and porter brewery does not differ essentially from that of a lager beer brewery. The chip-cask cellar of the lager beer brewery however, can be dispensed with, a carbonating room taking its place, while the stock cellar is retained, since some of the ales are stored.

CREAM OR PRESENT USE ALE.

Material.—Seventy per cent of malt, 30 per cent of unmalted cereals; or 75 per cent of malt, and 25 per cent of sugar added in the kettle.

Mashing Method.—Initial temperature 122° F., hold 30 minutes, run in corn mash, hold at 154° F. for 30 minutes, run up to 162° F., mash until conversion is complete, rest one hour, tap, boil like lager beer, adding from one to one and one-half pounds of hops per barrel. Add sugar (if used) 30 minutes before running out. Balling of wort, 14 per cent. Cool, give from one-half to one pound of yeast per barrel. Use skimming system. After yeast-making is over, let settle for two days, fill into trade barrels, and add 10 per cent Kräusen taken 36 hours after pitching.

For treatment of grits, flakes, etc., see "Mashing Operations" for Lager Beer.

BRILLIANT ALE.

Brew like present use ale. Balling of wort from 13 to 15 per cent, hops one and one-half pounds per barrel.

Fermentation.—Skimming system. (See "Stock Ale" and "Brewing in England.") After yeast-making is over let settle for two days, bring into storage tanks at temperature of cellar (44° F.). Add finings, pump over in 5 to 6 days, fine again, cool to 36° F., carbonate, filter and rack, or run from storage tanks to chip-cask when there is no carbonator, fine with isinglass and treat generally like lager beer. Temperature of chip cellar about 39° F.

Kräusening with lager beer Kräusen cannot be recommended, as the character of the product then approaches too much that of *lager.*

STOCK ALE.

Material.—Pale malt alone, or with 25 per cent of sugar.

Mashing Method.—Initial temperature of mash from 149° to 151° F., run hot water through underlet or pfaff to raise the temperature to 154° F., mash until inversion is complete, rest for one hour, use from two to three pounds of hops per barrel, adding one-third after all the spargings are in and wort boils, one-third after boiling one hour; boil one hour longer, and add the last one-third about ten minutes before running out. Balling 16 to 18 per cent. If sugar is used, add 25 per cent 30 minutes before running out.

Sparging water should have following temperatures: First, 176° F.; second, 170° F.; third, 165° F.; fourth, 165° F. (See also "Brewing in England.")

Fermentation.—Cool the wort to 59° F., add one and one-half pounds of yeast per barrel, let temperature rise to 70° F., after 36 hours rouse for 30 minutes, and run the ale into skimmers, i. e., vats in which the yeast is skimmed off. After yeast-making is over let settle for two days, run into trade barrels, add one-quarter pound of a good quality of dry hops per barrel, and prime with one pint of a 30 per cent solution of cane-sugar per barrel. Store from three to four months. (See also "Brewing in England.")

STOUT AND PORTER.

The principal requirements, as compared with ale, are greater palate-fulness, pronounced malt flavor and darker color. It is best to use mixed malts, i. e., a mixture of high and low kiln-dried malts. If this cannot be had, caramel malt, "black" malt, and sugar coloring to the required amount should be added.

The mashing method and general treatment of porter and stout are the same as for stock ale.

Hops.—Porter, one and one-quarter pounds per barrel; stout, two and one-half pounds per barrel. Added in the same manner as to stock ale. Sugar (if used) to the amount of 25 per cent, added in the kettle 30 minutes before running out. Porter, 13 per cent Balling strong; stout, from 16 to 18 per cent Balling.

Fermentation like stock ale. No dry hopping. Store three to four months.

BOTTLED GOODS.

Stock beer for bottling (ale or stout) should go through ordinary cask-fermentation (secondary fermentation) and after about three to six months it should be filled in bottles, while moderately lively, at from 65° to 70° F., when it will raise sufficient gas .o become brisk again and have a pungent flavor. Beer bottled previous to secondary fermentation becomes too wild in the bottles. The bottle stock beers are not pasteurized. (See also "Brewing in England.")

AMERICAN WEISSBEER.

The process of manufacture of this beer may be copied from the German methods. However, the material employed and method of mashing is usually quite different. Wheat malt is sometimes, but not generally, used. Instead, grits are employed to the amount of about 30 per cent, together with pale malt The grits are treated as usual, the mash is started at about 40° R (122° F.), and temperature raised by addition of grits mash and water to about 58° R. (162° F.). The wort is boiled for a short period (about 30 minutes) with hops from one-half to three-quarters pound per barrel.

Strength of wort about 10 to 12 per cent Balling.

For treatment of beer during fermentation, see "Berliner Weiss Beer." Ale yeast should not be employed as is often the case but yeast from a Weiss beer yeast should be obtained in case of need. In America the fermentation is generally conducted in vats instead of casks, in which case the yeast is skimmed off.

After fermentation the beer is kräusened and filled in bottles.

Undoubtedly the American article could be much improved by employing the materials, as well as the mashing method in vogue in German Weiss beer breweries, especially the material, as grits will under no circumstances yield those albuminoids that give Weiss beer its character, as wheat malt does. Certainly there seems no reason why American Weiss beer brewers should not be able to procure a good wheat malt.

Weiss beer in America is sometimes stored, bunged, and fined like lager beer, but a brilliant Weiss beer does not seem to catch the fancy of the consumers, who are accustomed to the cloudy, lively article of Berlin fame.

For details of Weiss beer production in Germany see next page.

KENTUCKY COMMON BEER.

Like California steam beer, Kentucky common beer is mainly consumed by the laboring classes, and is chiefly brewed in Louisville, Ky. It is marketed while still in an early stage of fermentation.

Materials employed are: Barley malt and about 25 to 30 per cent of corn, with some sugar color, caramel or roasted malt to give a dark color.

Balling of wort about 10 to 11 per cent.

Mashing temperatures vary greatly, both low and high initial temperatures being taken. In the latter case the corn mash is cooled with water before running into the mash-tun.

Boiling.—The wort is boiled with about one-half pound of hops per barrel, and cooled to 60° F. (12° to 13° R.).

Fermentation.—The wort is pitched with one-third of a pound of top-fermentation yeast per barrel, allowed to come full in Kräusen, and then transferred from the fermenter directly into the trade packages, which are placed on troughs, into which the yeast is allowed to work out. The barrels are kept full continually by topping up every few hours. After 48 hours in the barrels the fermentation is over and the barrels are bunged; when very much gas is required they may be closed in 24 hours.

The beers are not as a rule Kräusened, nor fined, and consequently have a "muddy" appearance, but a moderately clear article can be obtained if the saloonkeeper lays in a supply so that it can settle a few days before tapping.

TOP-FERMENTATION GERMAN BEERS.

BERLINER WEISSBEER.

Of the many varieties of top-fermentation German beers, it is only *Weiss beer* that has been able to compete with the lager beers, while the others, being gradually displaced, are but little known, or enjoy only a local reputation.

Although the methods for the production of Weiss beer vary considerably in different parts of Germany, it may be of interest to consider only the Berliner Weiss beer, as that is the kind which seems to have outstripped its rivals in Germany in point of quantity consumed, as well as in the United States, where it is considered the one type worthy of imitation.

Berliner Weiss beer should have a very pale color; be moderately clear, distinctly tart, rich in carbonic acid, so that it

ıams strongly when poured, and should hold the foam moder- :ely well.

There are quite a number of variations of methods employed ı the production of this beer, even in Berlin, but we will con- :nt ourselves with giving only one in detail.

The Materials employed are wheat malt and barley malt, hops ıd water. Three parts of wheat malt to one of barley malt 'as formerly considered to be the proper proportion, but since a reater degree of transparency is required of the product, the in- ination is of late to take less wheat malt. The original Balling f wort is about 10 to 12 per cent, amount of hops about three- uarters of a pound per 100 pounds of malt, or about one-quarter f a pound per American barrel.

The water employed should contain some salt and gypsum. f it does not, it may be prepared by adding about five pounds f table salt per 100 barrels, and as much gypsum.

Mashing Operations.—Three parts of wheat malt previously ampened, so as not to be crushed too finely, and one part of arley malt are run through the fore, or outside, masher, to- ether with cold water, and the temperature raised by running ı hot water from the mash pan to the very thick mash until 38° .. (118° F.) is reached. Part of the hot water (about one-third) , left in the pan, to which about three-fourths pounds of hops is dded per 100 pounds of malt, and boiled from 20 to 30 minutes. 'hen, a "lauter-mash" is drawn, run into the pan, and boiled to- ether with the hop decoction for a few minutes and returned ntil the temperature of the mash reaches 48° R. (140° F.). The rst thick mash is then drawn, boiled five minutes and returned, ringing the temperature of the mash up to 55° R. (154° F.). A :cond thick mash brings the temperature up to 60° R. (157° F.). The mash now rests about 40 minutes, when the wort is tapped nd immediately run over the surface cooler and through pipe oler, into the fermenter, where yeast is added.

It is noteworthy that the Weiss beer wort is not boiled, and onsequently the genuine Berliner Weiss beer is not so clear, wing to the large amounts of proteids it contains, in comparison) those beers for which the wort is boiled, as is the case with ostock, Hanover, Thuringian and Saxon Weiss beer.

Fermenting Operations.—The pitching temperature is about ı° R. (59° F.) in summer and 14° R. (64° F.) in winter. The

yeast may be added to a small quantity of the first wort, say ten pounds per barrel, and when in Kräusen, mixed with the wort in the starting tub (Ansetzbottich), letting the remainder of the wort run in as it comes from the cooler, rousing from time to time as long as it runs. The amount of yeast may be from one-half to three-quarters of a pound per barrel. The temperature during fermentation should not rise above 18° R. (85° F.), and should preferably be kept down to 16° R. (68° F.).

Some time after pitching a white foam becomes noticeable, and the beer is then transferred to the fermenting casks or barrels, holding usually about 30 to 90 gallons, where the foam, and subsequently the yeast, is allowed to work out of the bunghole into a trough, or a yeast vat, that is placed between two casks, laid so that their bungholes incline toward each other over the yeast vat. Soon a white foam is ejected out of the bunghole, which is collected in the yeast vat, and the beer collected from this collapsing foam (Abseihbier) is subsequently used for "topping up."

About 24 hours after pitching, yeast makes its appearance, the foam becoming more sticky, yellow, and larger bubbled. The yeast-making continues for about 24 to 30 hours, and during this time the foam is gathered in clean yeast vats, and the casks must be continuously kept full by topping up, as otherwise the yeast would not work out properly, would partly sink in the beer and impart to it a yeasty taste.

The fermented beer, with 3 to 5 per cent Balling, is drawn into separate casks, where it receives an addition of Kräusen, either at once or as soon as the beer is wanted. The amount of Kräusen depends upon the presumable length of time that the beer is to keep before consumption.

The beer, after Kräusening, is at once filled into bottles or jugs, where it is kept for about 8 to 14 days before it is ripe. Such beer receives about 25 per cent of Kräusen. If it is intended to keep longer it receives less Kräusen, as is the case for the export article, which is expected to keep four or six weeks in the bottle in a cool place.

The beer forms a heavy yeast sediment in the bottle, for which reason it must be carefully poured, after opening the bottle *with caution* to avoid agitation.

BROYHAN.

This is a Weiss beer, first brewed in Hanover as far back as the beginning of the sixteenth century. The genuine article has the appearance and bouquet of young wine, and a sweetish, tart taste. It is produced from barley malt and hops, without wheat malt, and is but slightly fermented. Single Broyhan is brewed with about 8 per cent Balling, double Broyhan, about 12 to 13 per cent Balling. The beers contain a low percentage of alcohol.

Beers similar to Broyhan are *Kotbusser Beer* and *Goslarer Gose.*

GRAETZER BEER.

This is a peculiar German local beer, produced from about two-thirds of smoked wheat malt, and one-third of barley malt. The wheat is steeped for 30 to 40 hours, germination is allowed to proceed at rather high temperatures so that the rootlets mat densely. Oakwood is used for fuel in drying the malt, the smoke passing through the malt, giving it a peculiar odor. The final kiln temperature is 40° to 45° R. (122° to 133° F.).

The wort is made on the infusion plan; initial temperature 20° R. (77° F.), end temperature 58° to 60° R. (163° to 167° F.), produced with hot water in about an hour. The wort is boiled as usual, one and one-quarter pounds of hops being added. Gravity of wort 7½ to 8½ per cent Balling. Hops are strewn over the grains before sparging.

Fermentation is carried out as for Weiss beer, after which it is put into packages of one to two barrels, which are bunged and left to stand for two to three weeks. Then the beer is bottled and stored at a temperature of about 8° R. for about two to three months.

The color of the beer is like that of Pilsener, and the taste is said to be deliciously tart and wine-like.

SPONTANEOUS FERMENTATION BEERS.

BELGIAN BEERS.

The first beer fermentations known were, of course, incited by yeasts finding their way accidently into the wort, and many local beers in different countries are still produced on this plan. But nowhere have such beers so extensive a market as in Belgium, where lager beer breweries are very few and where the top-fermentation beers divide honors with the spontaneous fermentation *types, of which there* are three: Mars, Faro and Lambic.

Mars is a beer of little gravity, Lambic is of high gravity, Faro of medium gravity.

Materials: These beers are made with 40 to 50 per cent of raw wheat, mixed with barley malt.

Mashing Methods.—The mixture is put into the mash-tun, water is run in, giving an initial temperature of about 40° R. (122° F.). Part of the mash then goes into the mash pan where it is saccharified at about 54°. R. (154° F.), then boiled and returned to the main mash, raising the temperature to about 52° R. (149° F.). Another thick mash is taken, raising the temperature after its return to 56° R. (158° F.), and a third thick mash brings it to 60° R. (167° F.). This wort is very dextrinous.

Fermentation.—When it has cooled to about 8° to 10° R. (50° to 54° F.) it is run at once into casks, receiving no yeast whatsoever. There it ferments by means of wild yeasts. The casks are stacked one over the other and communication with air is allowed through a very small hole. Fermentation becomes noticeable two or three days, sometimes a week, after the wort has been introduced into the cask, depending mainly upon the temperature of the cellar. A black, thick liquid oozing out through the hole indicates the progress of fermentation. After about two weeks of fermentation this hole becomes closed, owing to the thick liquid drying and becoming solid. The beer is then left in storage for a long time, extending up to two, three or even five years.

It is brewed only in the winter from October to April. Every year, when summer comes, this beer begins to work again. After two years it remains still. The brewer samples the casks, and if the beer is very bright, the taste clean and to the customer's requirement, it is taken out and run into the shipping casks.

The beer so obtained is very acid, containing great quantities of lactic acid. The very acid Lambic is bottled and keeps very long. It is called *gueuse lambic*. These beers are often seasoned with sugar. Then they constitute a drink that is both sour and sweet

COMPOSITION OF VARIOUS BEERS.

AMERICAN LAGER BEERS.		Time of Analysis.	Balling of Beer.	Balling of Wort.	Water.	Alcohol by Weight.	Real Extract.	Albuminoids.	Sugar.	Lactic Acid.	Ash.	Phosphoric Acid.	Analyzed By	Obtained in
Average of 14 samples........		1873	5.1	13.85	.....	3.83	6.19	0.69	1.63	0.189	0.30	0.116	Doremus.	New York.
Average of 170 samples........		1885	4.00	13.30	90.45	3.75	5.80	.....	...	.....	0.26	0.096	F. E. Engelhardt.	New York.
Av. of 222 samples of lager beers from all parts of U. S.		18[illegible]	4.1	13.49	90.36	3.85	5.79	0.62	1.53	0.124	0.26	0.095	Doremus, Engelhardt Crampton, Lattimore	New York. Different States.
Average of 15 samples........		1887	4.53	13.73	.....	3.77	6.46	0.51	2.00	0.16	0.194	0.072	Wahl and Henius.	Different States.
Average of 88 samples		1889	4.85	13.30	.....	3.64	6.21	0.50	1.99	0.11	0.20	.....	"	Different States.
Average of 210 samples......		1890	3.93	13.45	.....	4.01	5.70	0.56	1.20	0.10	0.18	.....	"	
Average of 176 samples. ...		1893	3.06	12.53	.....	3.61	5.50	0.390	1.62	...	.....	.....	"	
Beers from 10 different cities.	A.	1895	3.30	12.35	.....	3.72	4.91	0.41	1.29	0.09	.....	0.066	"	
	B..	1895	4.64	13.04	.....	3.45	6.15	0.39	1.62	0.120	.....	0.058	"	
	C.	1895	4.09	14.23	.....	4.16	5.92	0.44	1.83	0.103	.....	0.060	"	
	D..	1895	2.88	13.62	.....	4.41	4.80	0.45	1.39	0.102	.....	0.069	"	
	E..	1895	3.82	12.46	.....	3.53	5.46	0.37	1.45	0.136	.....	0.075	"	
	F.	1895	2.91	12.18	.....	3.81	4.56	0.33	1.50	0.069	.....	0.053	"	
	G.	1895	4.00	11.93	.....	3.26	5.41	0.48	1.97	0.085	.....	0.068	"	
	H.	1895	4.97	14.57	.....	3.82	6.73	0.46	3.36	0.126	.....	0.075	"	
	I..	1895	3.12	13.45	.....	4.25	4.95	0.33	1.50	0.073	.....	0.060	"	
	J..	1895	3.37	13.10	.....	4.00	5.10	0.35	1.25	0.054	.....	0.060	"	
Average of 247 samples.......		1896	3.60	12.93	.....	3.82	5.29	0.46	1.62	0.101	.....	0.068	"	Different States.
Canadian lager..............		1900	3.15	12.1	.....	3.77	4.88	0.61	1.13	0.072	.....	0.063	"	
Mexican lager................		1900	3.37	12.51	.....	3.77	4.97	.....	1.61	....	.....	.....	"	
Mexican lager		...	.....	13.27	.....	4.01	5.25	0.5	1.114	0.124	0.203	0.089	"	
Am. tonics, Av. of 10 samples.		1896	6.81	18.61	.....	4.88	8.85	0.67	3.88	0.141	.....	.....	A. Long.	
Some typical American tonics.	A..	1896	7.82	17.27	.....	3.88	9.51	0.63	3.87	0.208	.....	0.105	Wahl and Henius,	
	B,	1896	13.74	18.74	.....	2.06	14.62	0.85	9.84	0.113	.....	0.140	"	
	C,.	1896	7.41	20.78	.....	5.50	9.78	0.64	4.94	0.180	.....	0.107	"	
	D..	1896	5.23	17.01	.....	4.87	7.27	0.51	2.60	0.090	.....	0.085	"	
	E..	1896	5.47	16.86	.....	4.69	7.48	0.88	2.87	0.212	.....	0.129	"	
	F..	1896	7.58	17.46	.....	4.06	9.54	0.77	0.96	0.288	.....	0.155	"	
	G..	1896	8.20	21.70	.....	5.69	10.72	1.26	3.58	0.216	.....	0.114	"	
Some typical Am. temperance beers.	A..	....	2.15	6.66	.....	1.88	3.05	0.18	0.85	0.063	.....	0.03	"	
	B..	....	5.50	8.31	.....	1.22	6.07	0.09	2.55	0.036	.....	0.02	"	
	C..	....	3.27	6.66	.....	1.44	3.90	0.19	2.55	0.025	.....	0.025	"	
	D..	...	1.95	6.55	.....	1.94	2.80	.....	.....	..	.....	....	"	

COMPOSITION OF VARIOUS BEERS—(Continued).

Ales, Porters, Stouts and American Weissbeers.	Date of Analysis.	Balling of Beer.	Balling of Wort.	Water.	Alcohol by Weight.	Real Extract.	Albuminoids.	Sugar.	Lactic Acid.	Ash.	Phosphoric Acid.	Analyzed By.	Obtained In.
ALES.													
Bass & Co.'s Pale Ale	1896	1.8	11.96	....	5.58	4.32	..	0.76	0.234	....	.....	Doemens.	Munich.
Bass & Co.'s Strong Ale	1896	8.8	24.2	...	6.85	11.8		3.81	0.288	....	.....	Doemens.	Munich.
Bass & Co.'s Pale Ale ..	1888	2.75	17	88.57	6.06	5.35	...	1.51	0.180	....	.....	C. Gottfried and C. Rach.	Munich.
Bass & Co.'s Pale Ale	1887	2.4	15.71	89.42	5.08	4.42	0.50	0.49	0.117	0.31	0.056	C. A. Crampton.	Wash., U.S.A.
Bass & Co.'s bottled Dog's Head..	1901	0.87	16.08	80.85	6.45	3.70	0.58	0.67	0.171	....	0.0585		
Bass & Co.'s bottled White Label.	1901	1.92	15.65	80.68	5.80	4.52	0.56	0.61	0.171	....	0.054		
Bass & Co.'s draught Pale Ale	1901	3.45	15.70	80.06	5.18	5.76	0.58	1.68	0.144	....	0.0 6		
Allsopp Burton light dinner Ale.	1896	2.0	13.35	....	4.65	4.05	...	0.70	0.198	....	.....	Doemens.	Munich.
Allsopp Burton Ale	1879	3.60	16.97	80.33	6.30	4.37	0.45	...	0.235	....	.026	Lawrence and Reilly.	
Allsopp's India Pale Ale, Red Hand.	1901	2.23	15.11		5.44	4.70	0.44	0.63	0.144	....	0 .045	Wahl and Henius	Chicago.
McEwen's Sparkling Ale ..	1901	3.35	21.62	85.55	7.80	6.65	0.85	2.07	0.378	....	0.0703	Wahl and Henius.	Chicago.
Wm. Younger & Co.'s Sparkling Ale, Monk Brand.	1901	1.87	18.03	...	6.84	4.90	0.61	0.80	0.153	....	0 0.067	Wahl and Henius.	Chicago.
Odd English Ale, Dog's Head Bottling	1901	3.92	21.30		8.75	7.50	0.91	1.60	0.162	...	0.0855	Wahl and Henius.	Chicago.
Somerset draught ale 3 years old.	1882	2.15	22.63	85.71	8.57	5.40	0.71	1.36	0.63	....	.....	Ch. Graham.	
Worthington Burton Ale, 18 months old	1890	7.50	24.2	..	7.85	....	....	....	0.3085	as		Brown and Morris.	
Worthington Burton, bottled, 30 years old ..	1890	7.50	25.8	...	8.70	..	.	....	0.6085	acetic acid		Brown and Morris.	
Hannover Pale Ale Union Br....	1884	2.50	15.46	..	4.51	6.44	0.78	...	0.138	0.24	0.065	J. Skalweit.	
Christiania Pale Ale Ringnes & Co.	1884	5.7	14.45	88.19	4.00	6.45		.	0.13	..	.....	Zetterlund.	
American Ale	1887	4.50	16.52	88.73	5.25	6.02	0.57	1.47	0.094	0.33	0.057	C. A. Crampton.	Wash., U.S.A.
American Ale	1887	3.15	19.39	87.09	6.92	5.55	0.73	0.93	0.382	0.47	0.077	C. A. Crampton.	Wash., U.S.A.
American Stock Ales, average of 3 samples	1896	3.21	16.73	....	5.55	5.61	0.49	1.81	0.258	....	0.061	Wahl and Henius.	Chicago.
American Cream Ale..	1901	2.25	13.60	....	4.75	4.45	0.37	1.06	0.144	....	0.04	Wahl and Henius.	Chicago.
American Sparkling Ale	1880	3.98	13.98	....	4.68	5.82	0.40	1.52	0.135		0.06	Wahl and Henius.	Chicago.

COMPOSITION OF VARIOUS BEERS—(Continued).

ALES, PORTERS, STOUTS AND AMERICAN WEISSBEERS. (Continued.)	Time of Analysis.	Balling of Beer.	Balling of Wort.	Water.	Alcohol by Weight.	Real Extract	Albuminoids.	Sugar.	Lactic Acid.	Ash.	Phosphoric Acid.	Analyzed By.	Obtained In
ALES—CONTINUED.													
American Sparkling Ale.	1901	2.15	13.86	.....	4.90	4.40	0.38	0.91	0.135	....	0.04	Wahl and Henius.	Chicago.
American Pale Ale.....	1900	3.56	13.05	.....	4.01	5.35	0.37	1.34	......	....	.....	Wahl and Henius.	Chicago.
Canadian Stock Ale..............	1900	3.20	14.45	.....	4.75	5.30	0.51	1.36	......	....	.....	Wahl and Henius.	Chicago.
STOUTS.													
Guinness' Extra Bottled Foreign Stout, white label..............	1901	3.40	18.22	87.56	6.29	6.15	0.75	0.97	0.243	....	0.108	Wahl and Henius.	Chicago.
Guinness' Extra Stout............	1896	4.50	17.6	.....	5.64	7.02	....	1.08	......	....	.....	Doemens.	Munich.
Allsopp Luncheon Stout..........	1896	2.97	15.58	.....	5.35	5.37	....	1.53	......	....	.....	Doemens.	Munich.
Victoria Stout	1888	2.35	15.62	89.68	5.36	4.90	....	1.30	0.0556	....	.....	Doemens.	Munich.
Dublin Single Stout	1879	6.1	15.18	89.74	4.92	5.34	0.43	...	0.222	acetic acid	0.115	C. Gottfried and C. Rach.	Munich.
Dublin Double Stout	1879	2.9	20.63	86.60	7.23	6.17	0.78	..	0.364		0.173	Lawrence and Reilly	
Double Brown Stout, (Barklay, Perkins & Co.)...................	1884	4.0	18.78	87.28	6.00	6.78	....	....	0.46	0.39	....	V. Fodor.	Budapest.
Dublin Stout	1882	7.2	23.08	83.66	6.78	9.52	0.43	5.35	0.252	....	.....	Ch. Graham.	
English Stout	1887	3.7	18.16	87.57	6.13	5.90	0.76	0.57	0.151	0.37	0.049	C. A. Crampton.	Wash., U.S.A.
American Brown Stout..........	1900	5.45	18.15	.....	5.37	7.83	0.56	2.06	......	....	.....	Wahl & Henius.	Chicago.
PORTERS.													
American Porter.................	1887	6.7	17.97	86.32	4.89	8.19	0.76	2.67	0.166	0.41	0.100	C. A. Crampton.	Wash., U.S.A.
American Porter..........	1899	2.95	13.25	.....	4.19	4.87	0.40	1.49	0.135	....	0.061	Wahl and Henius.	Chicago.
Canadian Porter.....	1900	4.00	14.30	. ..	4.37	5.91	0.53	1.31	0.162	....	.....	Wahl and Henius.	Chicago.
AMERICAN WEISSBEERS.													
American Weissbeer.............	1900	2.52	9.29	.....	2.85	3.82	0.57	1.00	......	....	.....	Wahl and Henius	Chicago.
American Weissbeer....................	1901	2.24	9.28	93.45	2.97	3.58	0.42	0.91	0.342	....	0.036	Wahl and Henius.	Chicago.

COMPOSITION OF VARIOUS BEERS—(Continued).

German Austrian and Bohemian Domestic Beers.	Time of Analysis.	Balling of Beer.	Balling of Wort.	Water.	Alcohol by Weight.	Real Extract.	Albuminoids.	Sugar.	Lactic Acid.	Ash.	Phosphoric Acid.	Analyzed By.
Schenk or Winter Beers.												
Pilsener, Bürgerl. Brauhaus	1886	3.55	11.29	91.70	2.98	5.23	....	....	.....	0.196	.....	Fr. Kundrat.
Simmeringer	[illegible]	3.75	10.00	92.65	2.66	4.00	0.24	....	.....	0.15	0.051	L. Rosler.
Kleinschwechater	[illegible]	3.00	10.13	92.81	2.94	4.25	0.26	....	.....	0.14	.. ..	L. Rosler.
Nussdorfer	1876	3.75	10.78	92.15	2.93	4.92	0.30	....	0.09	0.16	.....	Fr. Schwackhoefer.
Erlanger	[illegible]	...	12.82	90.80	3.71	5.40	....	....	.....	0.28	.....	A. Hilger
Muenchener	1886	4.25	11.92	.....	3.00	5.92	....	....	.....	0.25	.....	C. Lermer.
Lager or Summer Beers.												
Bürgerl. Brauhaus Pilsen	1887	3.[illegible]5	11.72	.....	3.32	5.08	....	.....	0.12	0.18	......	E. Geissler.
Actien Brauhaus Pilsen	..	2.75	11.72		3.51	4.70	....	.....	0.12	0.19	....	E. Geissler.
Budweiser	....	2.75	11.34	92.21	3.55	4.24	0.28	.....	.	0.20	.....	Fr. Schwackhoefer.
Grazer	[illegible]	3.75	11.11	..	4.07	5.97	0.54	...	0.15	0.21	.....	L. Rosler.
Nussdorfer	....	3.75	13.18	90.57	3.85	5.58	0.42	....	0.14	0.22	.....	Fr. Schwackhoefer.
Simmeringer	..	5.00	14.86	89.20	4.06	6.74	0.45	....	0.20	0.21	....	Fr. Schwackhoefer.
Schwechater	.	4.25	13.25	90.37	3.62	6.01	0.52	....	0.13	0.21		Fr. Schwackhoefer.
Dortmunder Victoria Brauerei	1884	4.75	15.97	90.91	4.52	6.93	0.90	....	0.15	0.228	0.075	J. Skalweit.
Bremer Actienbrauerei	1884	4.00	15.45	.	4.62	6.21	1.11	....	0.142	0.23	0.095	J. Skalweit.
Hamburger Eibschloss	..	..	13.43	90.86	4.30	4.83	....	.....	.....	0.24	0.088	B. C. Niederstadt.
Konigsberger Schönbuscher	1880	4.50	11.21	90.27	4.48	5.25	0.44	1.04	.....	0.25	.....	E. Schrader.
Kieler, Waldschlösschen	1873	.	14.18	89.66	3.84	6.50	....	....	.....	......	0.088	Himly.
Berliner-Friedrichshöh	1887	6.00	16.54	. .	4.26	8.02	0.56	2.03	.....	0.247	.....	S. Bein.
Hannover, Einbecker	1879	3.50	13.70	90.32	4.62	5.66	....	.....	...	0.36	0.075	J. Skalweit.
Dresdener, Felsenkeller	1878	3.50	12.93	90.86	3.79	5.35	..	.	......	0.20	0.080	E. Geissler & G. Hofmann.
Baseler Fugirsthal	1869	3.00	12.90	90.82	3.72	5.46	.	1.07	.....	0.20	......	F. Goppelsroeder.
Baierer, Schwesinger	1878	4.75	11.01	89.69	3.70	6.61	....	.....	......	0.08	.....	Halenke.
Nürnberger, Actien (pale)	1884	4.25	14.85	89.42	4.27	6.31	1.08	....	0.145	0.22	0.103	J. Skalweit.
Erlanger	1875		13.13	90.93	4.06	5.01	....	0.42	......	0.24	......	A. Hilger.
Muenchener, Hofbräu	1846	....	14.81	89.21	4.02	6.77	....	0.351	0.202	......	......	Walkenroeder.
Muenchener, Hofbräu	1886	3.50	12.60	91.19	3.88	4.93	0.43	....	.....	0.23	......	C. Lermer.
Muenchener, Löwenbräu	1867	4.75	13.57	90.09	3.61	6.35	1.07	....	......	......	......	C. Praute.
Muenchener, Spatenbräu	1867	4.50	13.07	90.26	3.23	6.61	....	1.38	......	......	.....	C. Praute.
Muenchener, Löwenbräu	1888	3.56	14.75	91.19	3.46	5.33	....	2.60	0.223	.....	......	C. Gottfried and C. Rach.
Muenchener, Leistbräu	1888	3.75	14.62	88.64	3.74	7.66	..	2.30	0.19	......	......	C. Gottfried and C. Rach.

COMPOSITION OF VARIOUS BEERS—(Continued).

GERMAN, AUSTRIAN AND BOHEMIAN EXPORT BEERS.	Time of Analysis.	Balling of Beer.	Balling of Wort.	Water.	Alcohol by Weight.	Real Extract.	Albuminoids.	Sugar.	Lactic Acid.	Ash.	Phosphoric Acid.	Analyzed By.	Obtained In.
Pilsener, Bürgerliches Bräuhaus...	1883	3.55	....	89.92	4.60	5.48	....	...	0.18	0.18	0.07	A. Bertschinger.	
Pilsener, Actien Brauhaus.........	1883	2.75	....	90.98	4.60	4.42	.	....	0.144	0.176	0.065	A. Bertschinger.	
Pilsener, Actien Brauhaus..........	1897	....	12.21	...	3.82	4.82	....	....	0.045	.	......	C. Conrad.	Berlin.
Pilsener, Bürgerliches Bräuhaus..	1888	3.55	11.95	91.19	3.46	5.33	...	1.047	0.19	....	......	C. Gottfried and C. Rach.	Munich.
Pilsener, Bürgerliches Bräuhaus..	1898	3.80	13.82	....	4.20	5.70	...	1.18	0.19	....	......	Bernhold and Karabibarowic.	Munich.
Pilsener, Bürgerliches Bräuhaus..	1901	3.43	12.83	...	3.95	5.25	0.42	1.29	0.099	....	0.063	Wahl and Henius.	Chicago.
Pilsener, Genossenschafts-Brauerei	1901	4.61	14.29	....	4.07	6.48	0.52	2.15	0.108	....	0.0855	Wahl and Henius.	Chicago.
Pilsener, Anton Dreher............	1901	2.42	10.80	....	3.52	4.05	0.31	1.00	0.072	....	0.050	Wahl and Henius.	Chicago.
Michelober, Dreher................	1888	3.80	13.30	90.41	4.11	5.43	...	1.28	0.15	....	......	C. Gottfried and C. Rach.	Munich.
Kleinschwechat, Dreher...........	1898	3.95	13.07	....	3.83	5.67	....	1.54	0.13	....	....	Bernhold and Karabibarowic.	Munich.
Pilsener....	1887	2.20	10.34	92.82	3.28	3.90	0.35	0.79	0.11	0.19	0.05	Wahl and Henius.	Chicago
Schwechater	1876	4.80	....	90.48	3.52	6.00	0.47	....	0.13	0.19	......	Fr. Schwackhöfer.	
Liesinger.........................	1876	6.35	....	87.06	4.66	8.08	0.61	....	0.23	0.36	......	Fr. Schwackhöfer.	
Thüringer.........................	1898	2.84	....	....	3.11	3.74	....	....	....	....	....	Reinke and Donath.	Berlin.
Thüringer.........................	1895	3.45	12.50	91.17	3.78	5.07	0.41	1.67	0.09	....	0.08	Wahl and Henius	Chicago.
Hanover.....	1898	3.30	....	....	3.76	5.05	0.41	....	....	0.205	.....	Reinke and Donath.	Berlin.
Hanover, Actien Brauhaus........	1884	3.75	....	88.74	5.57	5.53	0.63	....	0.183	0.19	......	J. Skalweit.	
Kieler Actien Brauhaus...........	1880	....	....	87.45	4.40	8.15	....	1.56	....	....	....	A. Emmerling.	
Hamburger, Kopperhold...........	1881	....	....	90.31	4.40	5.26	....	....	....	0.29	0.096	B. C. Niederstadt.	
Hamburger..	1898	3.27	....	....	3.43	4.82	....	....	...	....	...	Reinke and Donath.	Berlin.
Dresdener Waldschlösschen.......	1878	3.80	....	90.31	3.59	6.10	....	....	0.17	0.28	0.086	J. Skalweit.	
Dresdener Waldschlösschen.......	1879	4.75	....	87.71	4.96	7.33	....	....	0.20	0.27	......	E. Geissler and G. Hofmann.	
Nürnberger, Robby......	1879	4.50	....	90.05	3.77	6.18	....	....	0.21	0.22	0.07	J. Skalweit.	
Nürnberger	1898	5.11	....	....	3.88	6.8	..	....	....	....	......	Reinke and Donath.	Berlin.
Nürnberger, Tucher...............	1895	5.15	....	88.62	4.31	7.07	0.51	2.06	0.135	....	0.095	Wahl and Henius.	Chicago.
Nürnberger, Henninger....	1881	3.55	....	90.41	4.61	5.82	1.08	.....	0.148	0.23	0.068	J. Skalweit.	
[illegible] Würzburg Export Beer.	1901	5.35	15.03	...	4.07	7.22	0.47	2.13	0.090	....	0.0675	Wahl and Henius.	Chicago.

COMPOSITION OF VARIOUS BEERS—(Continued).

GERMAN, AUSTRIAN AND BOHEMIAN EXPORT BEERS. (Continued.)	Time of Analysis.	Balling of Beer.	Balling of Wort.	Water.	Alcohol by Weight.	Real Extract.	Albuminoids.	Sugar.	Lactic Acid.	Ash.	Phosphoric Acid.	Analyzed By.	Obtained In.
Kulmbacher Actien Brauhaus	1884	6.40	...	85.99	4.31	8.51	1.12	.....	0.18	0.32	0.105	J. Skalweit.	
Kulmbacher	1888	7.55	17.60	86.09	4.18	9.7…	...	3.11	0.17	.....	.....	C. Gottfried and C. Rach.	Munich.
Kulmbacher		....	16.13	....	4.38	7.84	....	.....	0.07	.....	.....	C. Conrad.	Berlin.
Kulmbacher	1887	4.50	15.30	88.72	4.48	6.80	0.44	1.77	0.24	0.29	0.08	Wahl and Henius.	Chicago.
Muenchener, Löwen Brauhaus	1879	3.60	....	90.14	4.20	5.66	....	.....	0.23	0.22	.....	E. Geissler and G. Hofmann.	
Muenchener, Lowen Brauhaus	1901	4.13	13.53	....	3.96	5.95	0.44	1.57	0.090	.....	0.050	Wahl and Henius.	Chicago.
Muenchener, Spaten Brauhaus	1879	5.05	.....	89.67	3.74	6.50	....	.....	0.19	0.20	.....	E. Geissler and G. Hofmann.	
Muenchener, Sedlmayer	1886	4.55	.....	88.55	4.90	6.55	..	...	0.18	0.22	0.068	F. Schoffer.	
Muenchener	1888	4.79	.....	.....	4.16	6.71	.....		.....	.....	.....	Reinke and Donath.	Berlin.
Muenchener, Pschorr	1885	4.60	...	89.55	4.00	6.45		.....	0.14	0.186	0.062	L. Friedrich.	
Muenchener, Salvator	1887		18.80	..	4.61	10.25	....	.....	0.09	.....	.....	C. Conrad.	Berlin.
Muenchener, Pschorr	1886	6.12	....	.....	3.47	7.61	0.46	2.69	0.108	.....	0.08	Wahl and Henius.	Chicago.
Muenchener, Pschorr	1897	....	14.00	....	3.71	6.82	....	.	0.045	.....	....	C. Conrad.	Berlin.
Muenchener, Pschorr Bräu	1901	4.40	13.26	.....	3.72	6.12	0.41	1.72	0.072	.....	0.054	Wahl and Henius.	Chicago.
BOCK BEERS.													
Budapester	1884	5.55	....	88.55	4.19	7.26	....	.....	0.211	0.284	0.88	S. Fischer.	
Brünner	1876	4.40	.....	89.50	4.39	6.11	....	.....	0.19	0.27	...	Fr. Schwackhöfer.	
Kieler Actien	1884	4.05	..	90.32	4.03	5.78	....	.....	.....	.....	.....	C. G. Zetterlund.	
Dresdener Feldschlösschen	1879	4.50	..	89.01	4.31	6.65	..	.....	0.14	0.21	.....	E. Geissler and G. Hofmann.	
Hamburger Kopperhod		..	.....	88.41	5.30	6.29	..	.....	.....	0.32	0.109	B. C. Niederstadt.	
Schwechater	1876	4.25	.....	90.29	3.83	5.88	....	.....	.	0.14	0.21	Fr. Schwackhöfer.	
Einbecker Bock	1878	5.20	.....	87.20	5.39	7.41	....	....	0.15	0.34	0.085	J. Skalweit.	
Einbecker Bock Export	1883	....	15.58	....	3.76	8.04	....	.....	0.138	0.246	0.08	B. Niederstadt.	
Muenchener, Hofbrau (Einbock)	1879	8.49	......	83.70	4.75	11.61		...	....	0.24	0.39	E. Geissler and G. Hofmann.	
Muenchener, Spaten	....	8.47	.	82.65	7.00	10.35	0.71	1.02		.....	....	Aubry.	
Pilzener Bock Export	1878	5.25	18.23	86.85	5.08	8.07			0.22	0.28	0.095	J. Skalweit.	
Bremer Doppelt Lager	1878	1.01	23.28	85.92	9.20	1.88	....	.....	.....	0.21	0.082	L. Janke.	
Kulmbach Actien	1880	6.97	20.24	85.01	5.28	9.68			.....	0.15	0.35	E. Geissler and G. Hofmann	

COMPOSITION OF VARIOUS BEERS—(Continued).

German Top Fermentation Beers.	Time of Analysis	Balling of Beer.	Balling of Wort.	Water.	Alcohol by Weight.	Real Extract.	Albuminoids.	Sugar.	Lactic Acid.	Ash.	Phosphoric Acid.	Analyzed By.
Weissbeers.												
Hannover Städtisch	1878	7.20	9.44	91.64	1.08	7.28	....	....	0.18	0.18	0.05	J. Skalweit.
Hamburger Weissbier Br	1884	2.45	8.30	93.78	2.38	3.54	0.62	....	0.578	0.098	0.022	J. Skalweit.
Muenchener v. Schramm	1888	4.05	13.23	90.52	3.75	5.73	0.85	2.04	0.149	0.143	....	J. Skalweit.
Berliner Actien Br	1887	4.95	5.77	95.17	0.94	3.89	....	0.49	0.363	0.186	0.15	S. Bein.
Berliner G	1885	2.94	10.0	....	2.91	4.30	....	....	....	....	....	O. Reinke, Woch'schrift, xii. 32
Berliner Export B	1885	2.54	10.88	....	3.52	4.02	....	....	....	....	....	O. Reinke, Woch'schrift, xii 32
Berlin	1885	1.85	10.28	....	3.53	3.35	....	....	....	....	....	O. Reinke, Woch'schrift, xii. 32
Provinz B	1885	2.36	8.44	....	2.48	3.56	....	....	....	....	...	O. Reinke, Woch'schrift, xii. 32
Muenchener v. Schramm Weissbeer-Bock	1888	6.85	17.94	86.55	4.49	8.96	0.59	3.65	0.18	0.228	....	E. Wein.
Lichtenhainer	1886	4.25	9.26	93.76	3.0	3.22	....	0.66	0.238	0.128	....	J. Herz.
Lichtenhainer	1898	..	7.89	....	2.43	3.08	....	....	0.207	....	....	C. Conrad, Berlin.
Other Top-Fermentation Beers and Malt Extracts.												
Broyhan:												
Hannover Städt. Br.: Einfacher	1884	5.75	7.95	....	0.82	6.31	1.32	....	0.158	0.20	0.054	J. Skalweit.
Hannover Städt. Br.: Doppelter	....	....	13.22	....	0.96	11.30	1.67	....	0.06	0.23	0.123	J. Skalweit.
Münster Altbier: Von Appels	1883	1.30	12.25	92.19	4.45	3.35	0.33	0.58	0.372	0.294	0.062	König and Schwarz.
Münster Von Brüggemann	1883	3.00	12.67	91.08	3.87	4.93	0.52	0.72	0.444	0.306	0.055	König and Schwarz.
Dortmunder Adambier	1889	0.23	18.13	....	7.38	3.37	0.70	0.66	0.62	0.284	0.133	O. Reinke, Wochenschrift, 1889.
Dortmunder Adambier, 33 years old	1897	....	26.4	....	7.35	13.38	0.66	3.61	0.36	0.43	0.158	C. Conrad.
Chemnitz Städt. Br.	1878	3.10	7.95	93.84	1.92	4.11	1.06	....	....	0.11	0.94	C. Hebenstreit.
Braunschweiger Mumme	....	44.7	54.80	49.80	3.60	47.60	....	....		....	....	Kayser.
German Malt Tonics	1880	....	61.63	70.69	2.32	56.99	....	....	....	1.39	0.509	B. C. Niederstadt.
Braunschweiger Doppelschiffs-Mumme, F. Steger	1890	....	....	47.74	....	52.26	3.06	40.39	0.36	1.35	0.40	Aufrecht.
Joh. Hoff's Malzgesundheitsbier	1892	....	16.98	....	4.12	8.27	....	1.90	....	0.222	0.112	B. C. Niederstadt.
M. Hoff's Malz Extract, Hamburg	1892	....	16.53	....	3.12	10.72	....	1.99	...	0.248	0.084	B. C. Niederstadt.
Malz-Extract of Gronwitz Vienna	1888	8.5	17.42	87.74	5.16	7.10	0.47	....	0.27	0.19	0.073	L. Rösler.
Pale Ale	1887	10.3	73.34	52.29	25.62	22.10	2.95	3.61	0.475	1.047	0.322	Lendtner and Trillich.

COMPOSITION OF VARIOUS BEERS—(Concluded).

Miscellaneous Foreign Beers.	Time of Analysis.	Balling of Beer.	Balling of Wort.	Water.	Alcohol by Weight.	Real Extract.	Albuminoids.	Sugar.	Lactic Acid.	Ash.	Phosphoric Acid.	Analyzed By	Obtained In
Belgian Beers: Lambic	1839	2.87	21.19	86.58	7.77	5.65	....	1.06	1.11	....	....	Krandauer.	
Faro	....	3.25	13.81	90.52	4.33	5.15	....	0.71	0.90	..	....	Krandauer.	
Lambic	1871	2.25	17.21	89.14	6.38	4.48	....	0.66	1.06	..	....	Krandauer.	
French Lager Beers:													
Average of 67 samples	....	....	12.40	91.14	3.54	5.32	....	1.11	0.19	....	....	Ch. Girard.	Paris.
Tantonville Lager		....	15.58	89.21	4.70	6.00	....	....	....	....	....	Ch. Girard.	
Lille Lager	....		12.00	91.35	3.35	5.30	....	....	....	0.35	....	Ch. Girard.	
Spanish Beers: Bedika de la Cruz													
Blanka Imp. Bock Ale	1884	1.70	16.90	89.03	6.33	4.24	....	0.93	0.19	....	..	Zetterlund.	
Blanka Imp. Double Bock	1884	3.55	16.07	87.99	4.38	7.31	...	0.89	0.07	....	....	Zetterlund.	
Blanka Imp. Specialidade	1884	3.25	13.42	90.25	4.31	4.80	....	0.84	0.24	....	....	Zetterlund.	
Holland: Amsterdam Balkerbeer	1874	2.25	12.47	....	3.20	6.07	0.52	0.96	....	0.25	....	Krandauer.	
Amsterdam Amstelbeer	1884	5.37	15.27	88.67	3.94	7.39	....	....	0.28	....	....	Zetterlund.	
Haarlem Ale	1884	0.85	11.90	92.80	4.50	2.90	....	....	0.31	....	....	Zetterlund.	
Haarlem Stout	1884	3.90	14.31	90.07	4.19	5.43	....	....	....	....	....	Zetterlund.	
Sweden: Stockholm Export	1871	....	14.10	90.40	4.50	5.10	....	....	....	....	....	Aug. Almèn.	
Göteborg	1879	3.37	14.11	90.18	4.39	5.33	..	..	....	....	....	Aug. Almèn.	
Upsala Export	1879	8.82	18.15	85.64	3.79	10.57	....	....	....	....	...	Aug. Almèn.	
Oerebro Swedish Beer	1880	10.64	13.79	87.30	1.09	11.61	....	....	0.108	....	....	Oerebro Scient. Station.	
Oerebro Dünn Beer	1880	4.60	8.09	93.03	1.72	4.65	....	..	0.126	....		Oerebro Scient. Station.	
Norway: Christiania Pale Ale	1884	5.30	15.94	88.27	4.57	6.80	0.89	....	0.11	....	....	C. G. Zetterlund.	
Drammen, Salvator	1884	5.70	16.94	87.03	4.94	7.06	....	....	0.09	....	....	C. G. Zetterlund.	
Denmark: Gamle Carlsberg Lagerbeer	....	....	13.90	90.4	4.30	5.3	0.37	1.21	....	0.208	....	Gamle Carlsberg Laboratory.	Copenhagen.
Gamle Carlsberg Maerz or Bock	....	....	14.80	88.8	3.6	7.6	....	....	....	..	....	Gamle Carlsberg Laboratory.	Copenhagen
Japan: Asahi	1897	....	14.44	....	4.60	5.64	....	1.72	0.133	0.214	0.07	A. Lang.	
Kirin	1885	....	13.0	....	3.9	5.37	....	....	....	....	....	Doemens.	
Sapporo	....	....	14.2	..	4.01	6.47	....	....	....	....	....	According to K. Yagi.	

BREWING LOSSES FROM MALT MILL TO PLATFORM.

Brewing operations cannot be carried out in such a way as to deliver all of the valuable substances contained in, or derived from, the brewing materials into the packages that are placed on the platform of the brewery for delivery to the market, but the operations should be so conducted as to reduce the amount of valuable substances lost, to a minimum.

These losses are manifold and occur with almost every operation and every transfer of goods. They may be considered in the following order:

Loss from scouring;
Loss from malt hopper to mash-tun;
Loss from material gathering under false bottom (underdough);
Loss from incomplete gelatinization or inversion of starch;
Loss from incomplete inversion of albumen;
Loss from incomplete extraction of the grains;
Loss from boiling of wort with hops;
Loss from incomplete extraction of spent hops;
Loss from transfer of wort from kettle to settling tank;
Loss from incomplete extraction of the sediment ("Trub");
Loss during fermentation and storage;
Loss from finings, chips, filtration and racking;
Loss from racking bench to platform.

SHRINKAGE IN VOLUME FROM KETTLE TO STARTING TUB.

Besides these *real losses* there are *apparent losses*, owing to a shrinkage in volume unaccompanied by the loss of any valuable *substances. Such shrinkages are taken notice of as significant only between kettle* and starting tub, viz.:

Shrinkage of wort due to contraction by cooling from 212° F. in kettle to 43° to 48° F. (5° to 7° R.) in settling tank, approximately 4½ per cent.

Shrinkage due to evaporation on surface and Baudelot coolers (see "Cooling"), approximately 5 per cent.

Besides this apparent loss there is to be added the shrinkage due to a real loss, occasioned by:

Adhesion of wort to vessels like kettle, hop-jack, surface and Baudelot coolers, pumps and pipes, about ½ per cent.

Volume of spent hops and wort adhering is about two and one-half barrels per 100 pounds of hops, according to repeated tests made by M. Henius, or per 100 barrels of wort if 100 pounds are used, 2½ per cent.

Total shrinkage if hops are not sparged, and one pound of hops is used per barrel, 12½ per cent.

If hops are sparged the shrinkage is reduced by the number of barrels of water used for sparging, or, if five barrels are used per 100 pounds of hops, the total shrinkage would be 7½ per cent, or from 100 barrels of wort leaving the kettle 92½ would reach the settling tank.

Where less hops than one pound per barrel are used the total shrinkage may be readily calculated from above figures.

Example.—What is the total shrinkage if 70 pounds of hops per 100 barrels are employed?

Solution.—70 pounds of hops retain $\frac{2.50 \times 70}{100} = 1\frac{3}{4}$ barrels of wort.

Therefore total shrinkage, if hops are not sparged, is per 100 barrels of wort $10 + 1\frac{3}{4} = 11\frac{3}{4}$ barrels.

And if hops are sparged with three and one-half barrels of water the total shrinkage will be $11\frac{3}{4} - 3\frac{1}{2} = 8\frac{1}{4}$ barrels.

The only uncertain quantity in the above calculations is the amount of evaporation, which may vary considerably according to atmospheric conditions, system of cooling, etc. (See "Cooling.") It was found in one case by R. Wahl, where an atomizer was employed, to reach 10 per cent. Under ordinary circumstances it is safe to take 5 per cent as an average, if surface and *Baudelot* coolers are employed.

LOSS FROM SCOURING.

Malt is delivered to the brewer freed from sprouts, but is often passed through a cleaner, or scourer, before crushing, whereby ½ to 1 per cent more of substance is removed in the form of adhering rootlets, pieces of husk, etc. Such dust, according to Doemens, contained, on the average of seven tests, 23 per cent of extractive substances. Loss, through scouring 10,000 pounds of malt, would be 10 to 20 pounds of extract.

LOSS FROM MALT HOPPER TO MASH-TUN.

The loss from malt hopper to mash-tun. occasioned mainly by escaping malt dust in its transfer from crusher to tun, should be insignificant, but may amount to considerable if the malt dust finds easy egress through crevices or untight joints.

LOSS FROM FORMATION OF UNDERDOUGH.

This loss may be considerable if the mash-tun is of faulty construction, or mashing is carelessly done, at times the entire space under the false bottom being filled with underdough. For conditions favoring the accumulation of underdough see "Mashing Operations" and "Straining of Wort," also "Brewing Outfit."

This underdough contains a considerable amount of extract-yielding substances, and at times it may be composed mainly of finely divided starch that finds its way through the perforations of the false bottom. The weight of this underdough was determined in a case where all precautions were used to avoid its formation, and the mash-tun was of proper construction, and found to be 200 pounds wet, with 15 per cent of extract and 75 per cent of water. The weight of brewing material was 7,200 pounds of malt and 6,700 pounds of grits. Therefore:

Loss from formation of underdough from 10,000 pounds of material was about 22 pounds of extract, or 0.22 per cent.

The Brauerkalender of 1900, page 85, states that in a similar test made in a brewery on a large scale, the amount of underdough was found to be 70 pounds from 10,000 pounds of material, and contained 50 pounds of extract, a loss amounting, therefore, to ½ per cent.

These two cases probably represent the extremes and prove *how difficult it is* to obtain absolutely reliable results as to the *quantity of underdough* formed.

ANALYSIS OF AN UNDERDOUGH (BY WAHL AND HENIUS).

	Per cent.
Moisture	75.00
Dry substance	25.00
Extract in water-free substance	62.53
Of this there was soluble	22.63
Albumen in dry substance	34.88
Insoluble extractive matters	2.90
The Balling of the water filtered from the underdough was	7.30

LOSS FROM INCOMPLETE GELATINIZATION OF STARCH.

This loss may be considered together with the losses through incomplete extraction of grains.

The amount of loss from these two sources is usually determined together, and represents the extract that remains in the grains and is consequently lost for brewing purposes.

The amount of such extract varies from 5 to 10 per cent of the weight of the dry grains if the material is properly treated, and from 10 to 20 per cent if proper precautions are not used in mashing.

It is not at all unusual to find grains that contain 20 per cent of extract in the dry substance, which means a considerable loss.

We may take it that the ordinary brewing material will yield about 25 per cent of absolutely dry grains. Therefore, 20 per cent of extract in these dry grains would mean a loss of five pounds per 100 pounds, or a loss of 500 pounds for a brewing of 10,000 pounds of material. This loss can be reduced, by introducing scientific mashing methods, to about 1½ to 2 per cent, or 150 to 200 pounds per 10,000 pounds of material. This still means a loss of about four to five barrels of beer of 13 per cent Balling, whereas an amount of extract left in grains, of 20 per cent of the weight of the dry grains would mean a loss of about 15 barrels per 10,000 pounds of material.

An analysis of the grains is, therefore, a very simple and efficient means of determining the extent of one of the most prolific sources of loss in the brewery.

The amount of soluble extract in grains, due to imperfect sparging, can be readily determined by pressing the water from an average sample of grains taken from the grains box or pile.

and weighing this water with a saccharometer. The weight indicated by the saccharometer in degrees gives approximately the percentage of loss. Thus, an indication of 2 per cent would mean a loss of two pounds of extract for every 100 pounds of material, or 200 pounds for every 10,000 pounds of material, or about five barrels of beer of 13 per cent Balling.

Grains taken from a brewing that was properly made gave the following results:

	Per cent.
Moisture	81.6
Extract in water pressed from grains	0.7
The dried grains contained:	
Moisture	6.5
Oil	7.53
Albumen	33.75
Raw fiber	16.44
Ash	3.47
Extractive substance (starch, sugar, etc.)	7.50
Of which there was soluble (sugar, etc.)	3.08
Insoluble extractive matters (starch)	4.42

These grains were obtained from a brewing of 10,650 pounds of malt and 10,000 pounds of grits, or 20,650 pounds of material, and were dried in a grains drier. The total weight was 4,515 pounds, or 22 per cent of the weight of the material, while the weight of the wet grains was 24,538 pounds, or 119 per cent, or 19 per cent more than the weight of the materials.

LOSS FROM INCOMPLETE INVERSION OF ALBUMEN.

The albumen of malt is only partly inverted in the mash-tun, and approximately one-half of it goes into the grains while practically all of the albumen of unmalted cereals passes into the grains. More albumen will, however, pass into the wort if the mash is well peptonized, and the yield will be correspondingly higher than if this does not take place.

Two worts made from the same malt, but resulting from mashes, one of which was well peptonized, the other poorly peptonized, were found to contain 0.95 per cent, and 0.6 per cent, respectively, of albumen (see page 730); or, for 100 pounds of material, a loss of 1.8 pounds of albumen, or, for 10,000 pounds of material, 180 *pounds* of albumen. Considering the importance o *albuminoids in point* of palate-fulness and foam-holding capac *for the finished* product, the loss of extract in this case bec *doubly significant.*

[redacted]

LOSS FROM BOILING WORT WITH HOPS.

Here we encounter a loss in the essential oil of hops, which passes off freely with the vapors from boiling wort. This loss cannot be weighed. It has an important bearing on the hop aroma of the finished product, and the hops must be treated with this point in view. (See "Boiling Operations," p. 726.)

LOSS FROM INCOMPLETE EXTRACTION OF HOPS.

In some breweries the hops are not sparged with water at all, and the entire amount of wort held by them is lost. This amount is about equal to six times the weight of hops employed. Hence, 100 pounds of hops would retain 600 pounds of wort, and if this was 13 per cent Ball. the loss would be 78 pounds of extract, or about two barrels of wort, or for 10,000 pounds of material that yield about 190 barrels of wort, for which 200 pounds of hops may have been employed, there would result a loss of 156 pounds of extract, or about four barrels of wort.

In case the hops are sparged in the usual manner in the hop-jack, this loss is, of course, considerably reduced. It was found to be 40½ pounds where 13 barrels of water were used to sparge 260 pounds of hops, or 15 pounds per 100 pounds of hops. The weight of the wet hops from 250 pounds was found to be 1,690 pounds, and the saccharometer indication of the hop-liquid was 2.4 per cent.

LOSS BY TRANSFER OF WORT FROM KETTLE TO SETTLING TANK.

This loss is difficult to ascertain, and may be estimated as approximately ½ per cent. Thus, the loss from 10,000 pounds of material, from this source, would be about 50 pounds.

LOSS FROM INCOMPLETE EXTRACTION OF "TRUB" (DREGS, SEDIMENT).

The proteids precipitated by boiling the wort are quite voluminous. In American brewing operations they are separated from the wort in the starting tub, partly rising to the surface when fermentation begins, and forming the dark cover or scum which, when the beer is drawn off to the fermenting vat, is usually allowed to sink with the receding surface and to join with the sediment of the same nature. This "Trub," as it is called in German, retains quite a large amount of wort, which, according to experiments made by Lermer, approximated 2 per cent of the

total wort. This "Trub" should be collected in so-called sediment bags and allowed to drain, thus reducing, if properly done, the loss to about one-half to three-quarters barrel per 100 barrels, or about 300 to 400 pounds of wort per 10,000 pounds of malt, or about 40 to 60 pounds of extract per 10,000 pounds of malt. If no sediment bags are used, the loss may amount to about four barrels, or about 120 pounds of extract. The "Trub" from pure malt worts is much larger than from worts produced with the aid of unmalted cereals, when above figures may be reduced by a percentage equal to that of unmalted cereals employed, or the loss will be about one-quarter to one-half barrel for 30 to 40 per cent of unmalted cereals per 100 barrels, or about ¼ to ½ per cent.

The sediment bags should be washed with hot water after using, and from time to time boiled or steamed out. An addition of bisulphite of lime to the washing water from time to time aids in keeping them from souring or putridity.

LOSSES DURING FERMENTATION AND STORAGE.

During fermentation there is some evaporation; the sugar ferments to alcohol and carbonic acid, most of which escapes; part of the albuminoids and mineral substances of the wort are used up to nourish the yeast, and there is some waste from skimming off the covers, like hop-resin cover and final cover.

From the fermentation of so much sugar and the escape of carbonic acid gas incidental thereto, one should imagine that a contraction in volume took place during fermentation on this account. This, however, is not the case. A. L. Stern (Journ. Chem. Soc., through Am. Br. R., XIII, p. 414) found that the volume of a sugar solution is the same before and after fermentation, if no evaporation of water takes place. The deduction is that the expansion of the alcohol formed equalizes the contraction due to the removal of the sugar.

The loss during fermentation is not so great on this account as it otherwise would be. The loss due to the settling of yeast is approximately ½ per cent, and to evaporation, skimming and transfer, about 1 per cent, or, a total of about 1½ per cent.

During storage these losses continue in a measure, but the loss from evaporation is not so great. About ¼ to ½ per cent will cover the loss from yeast sedimentation and transfer mainly, so that *the total loss from settling tank to chip-cask is about 2¼ per cent.*

[redacted]

LOSSES FROM FININGS, CHIPS, FILTRATION AND RACKING.

In the chip-cask the loss becomes quite considerable, especially if no filter is used, on account of the absorption of a quantity of beer by the chips, and the sediment of finings and yeast clinging to them. Some water being used in the preparation of the finings, and the chips going into the cask soaked with water, the loss in volume is somewhat reduced, but the loss in extract or beer is equivalent, of course, to the quantity removed with chips and finings.

It was found that the amount of beer removed by 6,189 straight chips that were used in a 60-barrel cask, was 213 pounds, or, about 1¼ barrel per 100 barrels, or, about 80 pounds of original extract was removed with the chips per 10,000 pounds of material employed, without thereby decreasing the volume, since the beer simply displaced so much water in chips. The total losses in volume due to treatment in chip-cask, transfer to racking bench and filtration are estimated at about 1 per cent. They are less than formerly when no filter was used. Since the introduction of the filter less isinglass is employed and also less chips, reducing the actual loss considerably.

LOSSES FROM RACKING BENCH TO PLATFORM.

To these losses must be added the amount of beer served at the "Sternewirth" to working men and visitors, and which, of course, varies materially with the custom and output; ¼ per cent may be considered a fair amount for a large brewery, 1 per cent for a small brewery.

TOTAL SHRINKAGE.

Shrinkage in settling tank................	¼ to ½ per cent
Shrinkage during fermentation	1½ per cent
Shrinkage during storage	¼ to ½ per cent
Shrinkage in chip-cask and to racking bench	1 per cent
Shrinkage from racking bench to platform	¼ to 1 per cent
Total shrinkage for a large brewery from settling tank to platform.......	3½ per cent

Since 100 barrels of wort in the kettle give 92½ barrels in the *settling tank, if* the hops are properly sparged, and 100 barrels *in the settling* tank yield 96½ barrels at the racking bench.

One hundred barrels of wort run out of the kettle should give about 89 barrels of beer at the racking bench.

$$\frac{92\frac{1}{2} \times 96\frac{1}{2}}{100} = 89+.$$

One hundred and twelve barrels of wort run out of the kettle should give 100 barrels of beer at the racking bench

$$\frac{100 \times 100}{96\frac{1}{2} \times 92.5} = 112.$$

Where the brewery cooperage is quite small, this loss is increased. If hops are not sparged, the loss is 2 to 4 per cent higher.

Excise regulations demand the entry of the number of barrels of finished beer obtained from each brew, and not the number of barrels of wort obtained in the cellar. It is, therefore, necessary to make the proper deduction from the amount of beer in the kettle or from the amount obtained in the settling tank, before making the entries. The above figures will serve as a guide in this respect. Notice should be taken that where the hops are not sparged the reduction is several per cent greater, according to the amount of hops used and the amount of sparging water employed.

TREATMENT AND PROTECTION OF SURFACES.

The treatment of the different surfaces in the brewery can be classified as follows:

1. Cleaning operations.
2. Varnishing wooden brewery vessels.
3. Varnishing, lacquering and staining iron vessels.
4. Pitching wooden casks, kegs and barrels.
5. Covering surfaces for ornamental as well as protective purposes, such as painting, calcimining, whitewashing and varnishing.

CLEANING OPERATIONS.

These comprise:

Cleaning or scouring of floors, walls, ceilings, inside and outside of vessels, tubs, casks, conduits or pipes, and the removal of waste products.

The importance of cleanliness in every department of the brewery cannot be too emphatically impressed upon the brewer, especially the cleaning of vessels containing wort and beer, and the surroundings that can affect these.

As remnants of wort or beer, when exposed to the air, soon become breeding places for germs and micro-organisms which are always present in the air, any vessel that has been emptied should be cleaned as soon as possible, for the longer these remnants are allowed to remain, the more they dry by evaporation, and the more difficult it is to remove them. (See "Micro-organisms.")

The readiness with which a surface can be cleaned depends mainly upon the porosity of the material and the smoothness of its surface. Wood construction for floors, walls, beams, posts, cask supports, etc., being replaced in modern construction and outfits more and more by tiling, cement and asphalt, cleanliness is facilitated in proportion.

On hard and smooth impervious surfaces any impurities or foreign matters merely adhere, and can be readily removed, but on a substance of a porous nature these impurities, especially if they are liquid, will sink into the pores from which they can be removed only by tedious and lengthy operations of cleaning or scouring.

As aids and accelerators to the brush and hose in the different cleaning operations, various substances may be used that may be classified as antiseptics, solvents, corrosives and abrasives.

ANTISEPTICS.

Before mentioning the various antiseptics employed in the brewery, attention should be called to the danger that can arise from their improper use.

Caution.—Wort and beer are very sensitive substances, and readily take up foreign odors and flavors. Therefore, the brewer should well consider, before he uses any chemical, whether it can impart any flavor or odor, and also reflect upon the proximity of any open vessels containing wort or beer that might be affected. Furthermore the ventilation of the room in which these chemicals are employed must be taken into account.

The chemicals generally used are the following:

Lime or milk of lime is the most universal and at the same time one of the cheapest and safest antiseptics now in use, and is most effective when freshly prepared. It is made by slaking ordinary builders' lime, that is, by placing the lime in a shallow vessel and pouring over it one-half to three-fourths its weight of water. In a short time the lime becomes heated, emits vapors of water, swells up and finally crumbles to a white powder.

This powder, or slaked lime, is then stirred in water to a creamy consistency and the mixture passed through a fine sieve, in order to remove the particles of limestone always present, whereupon it is ready for use.

This milk of lime can be used anywhere in the brewery, except upon the ceilings over open fermenting vats, since the lime, if used there, might drop into the wort or beer.

Chloride of lime, bleaching powder, chlorinated lime, calcium hypochlorite, as it is variously designated, made by saturating slaked lime with chlorine gas, is a cheap and powerful antiseptic, but *should not be used in cellars* as its effectiveness depends *upon the action of* the liberated chlorine, which has a penetrating *disagreeable odor.*

Chloride of lime can be used in the malt house, wash house, stables, in fact, in any place not containing wort or beer or near enough thereto to affect it.

Bisulphite of lime, a liquid made by saturating a thin milk of lime with sulphurous acid gas, or sulphur dioxide, has also found an extended use in breweries, in fact, it ranks second to milk of lime in popularity. It emits a pungent odor of burning sulphur when in a concentrated state, but when diluted can be safely used in the same manner as milk of lime.

Acid fluoride of ammonia, or "antiseptic salt," is also very effective as an antiseptic agent. It attacks metal and glass strongly, One pound dissolved in 30 gallons of water can be used in place of bisulphite of lime of ordinary strength.

Antinonnin is a creosote derivative, made in Germany, and introduced into this country with good success. The method of application is not complicated, and since the product is used in a greatly diluted state, which adds cheapness to its commendable properties, it can be considered a good parasiticide and disinfectant for brewery use.

Antinonnin can be used with water or whitewash; the latter is perhaps preferable. (See "Whitewashing.")

Formalin has of late become a much used and effective antiseptic agent in packing houses and other industries, and is being recommended for brewery use in Germany, having, however, found little application, if any, in American breweries.

Formalin consists of a 40 per cent solution of formaldehyde in water and, in its concentrated state, has an irritating, pungent odor. It is a powerful antiseptic, more so than bisulphite of lime, which it resembles in many ways, excepting that it is more costly.

Commercial formalin should be diluted before use to such an extent that the odor of formaldehyde is faintly perceptible above the vessel containing it (diluted about 1-1000). As there are at present no reliable data at hand as to the effect of formaldehyde, if absorbed by wort or beer, great circumspection should be used in employing formalin in fermenting cellars or poorly ventilated rooms.

Permanganate of potassium, or a solution of this salt, is one of the most powerful antiseptics and oxidizing agents known.

It will, however, not find an extended application for treating large surfaces in the brewery on account of its great cost.

It forms with water a purple solution, which has neither odor nor pronounced taste and can, therefore, be used in every department of the brewery. Its principal effectiveness is in purifying or removing concentrated or neglected results of uncleanliness, such as in stables, urinals or catch-basins of sewers. To be most effective for these purposes the solutions should be made slightly alkaline by an addition of a small amount of caustic potash or soda.

SOLVENTS.

Carbonate of soda, either in the form of soda crystals and then ordinarily termed "soda," or in the form of a powder and then termed "soda ash," or "calcined soda," which is more effective than the crystal form, is especially effective in cleansing operations where organic substances are to be removed, on which it acts as a solvent, for instance:

Incrustations in vessels, like kettle or surface cooler, cooler pan, pipes, pumps, on attemperators, or remnants in bottles which are treated with a solution containing from 1 to 5 per cent of soda, according to circumstances.

Softening coatings of shellac or pitch, the precaution being used, however, not to dissolve the coating entirely if the vessel is to be recoated since the soda would penetrate the wood and create difficulties in revarnishing or pitching.

Dissolving resins and other organic matter from wood. It is therefore useful in treating ale packages and chips.

Caustic soda, or soda lye, is still more effective than soda ash, and is used hot for cleansing pipes, five to ten pounds per barrel of water being employed.

Ammonia. A solution of ammonia mixed with whiting or chalk, as a distributor, gives good results for cleaning and polishing copper and brass.

CORROSIVE SUBSTANCES OR ACIDS.

Sulphuric acid and *muriatic acid,* properly diluted, are often used in connection with some abrasive substance like emery or pumice stone, or some distributing material, than which there is none more effective than fresh yeast. The acids aid in cleansing by dissolving the oxides of the metals that have formed by contact with air, like iron rust or verdigris.

ABRASIVE SUBSTANCES.

Emery is a grayish-brown crystalline substance, possessing great hardness, and is therefore used as a grinding and polishing material. It comes on the market in different degrees of fineness so as to be used for various purposes. Emery is used almost entirely upon rough metallic surfaces, but should not be used on smooth polished metals, being too gritty and causing scratches.

Pumice Stone is a gray, porous stone found in the neighborhood of volcanoes. It is very porous, similar to coke, and is used as an abrasive similar to emery, being, however, better adapted to smooth metals, as it is not so hard or gritty as as emery.

Infusorial Earth, or Kieselguhr, is a chalk-like substance consisting of the skeletons of diatoms. It is of a siliceous character and on account of its comparative softness can be used on smooth surfaces.

Sand or Cinders. For scouring metals the hairs of a brush are too soft to be of much effectiveness, and for this purpose sand is used in connection with them. The sand for this purpose should be clean, that is, not mixed with clay or other soft and smooth substances.

Cinders are in universal use because they are always at hand, but before use should be sifted and only the finer particles used.

Proprietary cleaners now on the market, usually sold in tin boxes or cans, consist mostly of different abrasive materials, such as emery, tripoli, rotten stone, crocus or rough mixed to a paste with some fat or wax or, if liquid, with gasoline or oil as a vehicle for spreading. These cleaners are usually intended for nickel, copper and brass, for which purpose they generally give good results.

CLEANING OF BREWERY FLOORS, WALLS, VESSELS AND UTENSILS.

MILL AND BREW HOUSE.

Mill House Floors. Sweeping the floors with wet sawdust readily takes up the flour and dust adhering to it.

Malt Mill. Cleaning the malt mill is an easy operation if it is kept dry. All that is then necessary is to use a stiff brush and scraper for the corners and crevices. When there is a stationary connection between mill and mash-tun it happens frequently that

the slide in the spout was not closed after the discharge of the ground malt, causing the vapors from the mash to find their way into the malt mill, moistening and softening the malt flour retained therein. In such a case nothing but a thorough cleaning of the mill, after taking it apart, will answer.

Brew House. The walls and ceiling should be kept in proper cleanly condition, the frequency of washing depending upon the finish of their surfaces. (See "Painting, Whitewashing, Etc.")

The floors around the cooker, mash tub, kettle, etc., should be thoroughly scrubbed with water and broom after each brewing, provided the floors are of waterproof construction and have the proper drainage.

When washing wooden floors the addition of bisulphite of lime is advisable.

Hot water tanks are subject to the same trouble as boilers, namely, deposits of scale or incrustation of lime salts upon their inner surfaces, but to a less extent. If cleaned regularly with a steel wire brush they can readily be kept clean, but if neglected, require the same chipping and scraping as does a boiler.

Cold water tanks accumulate a slimy coating which can be readily removed by using a bristle brush, together with sand or cinders.

Cooker, pressure cooker, mash tub, hop-jack and surface cooler or beer tank should be cleaned as soon as possible after they are emptied in order to prevent souring of their contents. (See also "Varnishing and Staining Iron Vessels.")

They should be cooled before cleaning, and a man, working in a normal temperature, can do many times the amount of work he can do in a superheated one. This cooling is readily accomplished by spraying the inside walls and bottoms with cold water from a hose—in the mash tub and hop-jack running cold water through the over-sprinkler or sparger—whereby the vessels and contained air are quickly cooled.

The cooker and pressure cooker are readily cleaned by means of a brush and stream of water from a hose, the remnants of brewing materials being easily flushed through the sewer opening.

In the mash tub, cleaning is a more laborious operation. After the grains are thrown out by the machine, or by hand shovel, the false bottom or strainer is sprinkled with cold water and the the clamps unscrewed and the segments removed. It is th

usually found that the real bottom is covered with a considerable amount of what is styled "underdough," a pasty mass with considerable adhesion to the tub bottom. This mass must be thoroughly and completely removed, since it consists largely of starch and albuminoids especially prone to decay and putrefaction. This underdough requires for its removal a most energetic application of water spray, both hot and cold, and of the action of a brush or broom.

This same procedure also applies to the hop-jack.

The segments of the false bottom or strainer are then washed and scrubbed, and attention is here called to an extra manipulation not generally carried out. It is well to hold each of these false bottom segments against the light in order to see if all the holes are open, and if any are clogged up, to remove the obstructions with a wire or pin before relaying the bottom for the next brewing. It requires no explanation that as the holes become stopped up the running of the wort and extraction of the grains must become correspondingly sluggish.

If the inner surfaces of these vessels become crusted or coated with solid particles from the wort, which should not happen if regularly cleaned, such matters can be removed by scraping or with a steel wire brush and sand. After such treatment such vessels as were varnished should be revarnished.

Brew Kettle. In cleaning the kettle the neck should always be cleaned before the kettle proper. For this purpose a ladder is placed upon a scaffolding in the kettle, barely reaching into the opening of the neck.

For cleaning the kettle the brewer has a good agent which costs him nothing, by taking the beer yeast, of which about three gallons are mixed in a wooden bucket with about two gallons of finely screened light ashes or cinders. After the mass has been well mixed about one to one and one-half fluid ounce of commercial sulphuric acid or oil of vitriol should be added, and the mixture be again stirred thoroughly. An excess of acid will attack the copper too much and cause it to turn blue and lose its lustre.

After the entire upper part of the kettle has been rubbed bright, the yeast mixture is washed off with water and brooms and the whole surface spread over with a mixture of yeast and small amount of ashes, but without any acid, a fresh or washed

broom to spread the preparation being used, and the entire upper part once more rubbed down thoroughly. The yeast mixture is then left on the walls, the scaffolding removed from the kettle and the bottom part of the kettle treated in the same manner as the upper, that is, first treated with the thick yeast mixture with acid and afterward with the thin mass without acid. Finally, the mixture of yeast and ashes is scrubbed from the walls with water and brooms, and the vessel well rinsed with clear water. The interior surface should, after this treatment, be bright and smooth.

To clean the exterior surface of the neck and hood of the kettle a similar mixture of yeast and screened ashes, but without acid, should be used. The mass is spread on the surface with a brush, and rubbing kept up with the brush until the whole surface is bright, whereupon it is rinsed off with clear water and a fresh clean brush. For cleaning the brass ornaments that are attached to most kettles the ordinary metal polishes may be used.

Baudelot or Pipe Cooler. The first and most serious danger of infection that the wort is subject to commences as it passes over the pipe cooler, since the wort, previously hot, remains to a certain extent sterile. Any infection the wort receives on the cooler it retains through all subsequent stages in the brewery, even until finally marketed and consumed. The cleaning of this cooler, therefore, must be doubly thorough.

The straight tubes are readily cleaned, but this is not the case with the joints where the tubes enter the headers or return bends, and extra care and labor should therefore be expended when cleaning these joints.

The copper tubes, etc., are cleaned in extreme cases with the same mixture of yeast, cinders and acid used in cleaning the kettle, but the iron pipe lower part for ammonia should not receive any of this treatment as it would injure the black coating. The ordinary way for cleaning this cooler is to use a soda solution about 5 pounds per barrel, and allow this solution, while warm, repeatedly to run over the cooler until all sediment is loosened, when the cooler should be scrubbed with a brush and water.

The cooler pan, if of copper, is treated the same as the brew kettle. If of iron, it should be merely brushed and rinsed.

CELLAR VENTILATION AND CLEANSING.

The greatest difficulty in keeping cellars and their contained vessels in a clean and sweet condition is met with where the ventilation is inferior.

The cheapest and at the same time the most powerful antiseptic or germicide at our disposal is the absence of moisture or the dryness of a substance, since micro-organisms require water for their sustenance and propagation. This resistant property of dried substances is best illustrated to the brewer by calling attention to the length of time wet grains will keep as compared to the keeping quality of dried grains, or the time required for moist leather (boots and shoes) to accumulate a covering of mould when placed in a moist, dark closet, as compared to when they stand in the open air and sunlight.

Ventilation, or a current of fresh air replacing stagnant or moist air, has a drying effect and is therefore a purifier or antiseptic by itself, and it furnishes a cheap and efficient method that saves much labor and chemicals which are otherwise necessary.

In newly built cellars the proper ventilation ducts, etc., are generally supplied, but in older constructions these are very often lacking. Proper ventilation can be obtained in the latter by installing blowers or fans and blowing or forcing air through the cellar from time to time, or by drawing the air out by means of an ejector.

Attention should be called, however, to the necessity of having pure air for ventilation, since air that has previously passed over decaying matter or that contains dust from city streets may be so laden with micro-organisms as to cause the opposite of the effect desired. In summer the outside air forced through the cellars should therefore be filtered and also cooled, which can be readily done by passing the air over and through water.

The floors of the cellars should be scrubbed from time to time with milk of lime (above described), allowing this substance to remain upon the floor for some time before scrubbing and final removal by flushing with water. This is especially necessary in the corners and along the walls, also under the vessels or other out of the way places where the milk of lime should be liberally applied and allowed to remain an extra length of time. This

treatment with milk of lime goes far toward keeping the air in the cellars in a sweet condition.

Wooden floors are a source of constant annoyance to the brewer if he wishes to keep them in clean condition. Any yeast, wort or beer, if allowed to remain on a wooden floor too long, soon sinks into its pores and renders cleaning more difficult. Such matters should, therefore, be removed immediately by scrubbing and flushing.

Starting and Fermenting Tubs.—As these and subsequently described wooden vessels are usually varnished, excepting for ales, care should be taken that ladders with sharp edges or boots with protruding nails, etc., do not come in contact with their inner surfaces on account of the danger of piercing the coating of varnish.

Fermenters should be cleaned as soon after the yeast has been removed as possible, by using hose and brush freely, the tub being first flushed to remove the loose yeast. The most difficult part to clean is the top that contains a ring of dried-up yeast. albumen, etc., thrown off by the Kräusen foam during the early part of the fermentation. This is usually a dried resistant crust, clinging to the top and sides, but can readily be softened by smearing moist yeast over it. This soon softens the ring so that it can be removed by flushing and scrubbing with a brush, and usually not requiring scraping, which may injure the varnish. A paste prepared from not too finely ground stone or pulverized chalk, some milk of lime and water, when applied to this scum and then brushed, has given good results.

Attention should also be paid to the taphole, so that it does not retain any yeast that can come in contact with wort subsequently contained in the fermenter.

The water that remains upon the bottom, due to the latter's warping, should be removed by means of a sponge. The outside of the tubs should also be flushed and brushed, as it often happens that some of the Kräusen foam runs over the outside.

If a fermenter has been out of use for some time, even if it was properly cleaned when empty, it should be again flushed and brushed before use.

Vessels that have been out of use for a long time, especially if they stood in unoccupied or unused rooms, should be treated *with milk of lime* or bisulphite of lime and cleaned again.

The water used for rinsing any vessel containing wort or beer should be of good purity. When such cannot be obtained the vats must be thoroughly sprinkled after final rinsing with bisulphite of lime or another harmless antiseptic solution, and the vat thoroughly drained before use.

The scratch iron should not be used on varnished vessels, except as a final means when the above cannot be made to answer.

Attemperators, whether of copper or iron, are cleaned in the same manner as the Baudelot cooler tubes, if unvarnished. If varnished they should be brushed only, softening any adhering incrustation as above.

Accessories, such as yeast storage tubs, pails, sieves, dippers, should be cleaned directly before use and afterward. Those made of wood should be varnished.

Cleaning or Washing Chip-Casks and Chips.—After emptying the cask, the chips are gathered by a workman by means of a hook and a chip box, and carried to the chip washer. The chips should be distributed evenly through the drum and the vessel not filled to its utmost capacity in order to afford an opportunity for the chips, as the drum revolves, to drop and be subjected to friction, and expose all parts of their surface to the water. Nor should the jet of water be too powerful so as to prevent the dirty water from draining off properly. The drum, which may be operated either by hand or power, should be revolved continuously until the drain water runs off clear. The chips are then taken out and returned to the cask. The chips are first flushed with cold water, then with hot water, and finally with cold water to cool them.

While the chips are being washed another workman should be washing the cask, both inside and out, by throwing a weak jet of water from a hose.

A cask broom is then used and the cask well scrubbed, both lengthwise and crosswise, special attention being given to the spent yeast near the bung-hole. It should not be forgotten to rub off the iron bars or stay-bolts that run through the cask. The water is then swept out, the cask rinsed, this water again swept out, and any liquid settling in depressions removed by means of a sponge. One workman should then throw in the clean chips, which the other man who remains in the cask distributes evenly over the bottom. The door is rubbed around

the edges with tallow, and closed, and the cask thus made ready to be recharged.

In an emergency a cask may be charged two or three times without washing, but this is not recommended for a variety of reasons, and the proper procedure is to wash the cask each time after emptying. A separate cask for the residues is not necessary. These residues, together with the beer spilled at the racking bench, can be returned to the newly-washed cask.

Stock or Ruh Casks are cleaned in about the same general manner as chip-casks, except that it is necessary, in large ones, to erect a scaffolding in them in order to get at the top and upper sides.

Pipes and Conduits.—The most important consideration in erecting or installing pipe lines is, next to their being tight, to have them have perfect drainage. Pipes that are horizontal or curved retain wort or beer, which soon dries and becomes a source of infection.

Pipe lines with proper drainage are readily kept clean in the brew house by repeated flushing with hot water and steaming after each brew. Though the temperatures in the cellars are very low, an infection may readily take place if the pipes and conduits are not kept scrupulously clean by repeated rinsing and brushing.

In both places the pipes, besides the hot water and steam treatment, should be occasionally filled with a hot 5 per cent solution of caustic soda, which should remain in the pipes for some time, and then be removed completely by repeated flushings of the pipes and with both warm and cold water. This application of soda solution should be repeated, if necessary, until the pipes are thoroughly cleaned.

Rubber Hose is cleaned in the same manner as pipes, except that the soda solution should not be over 2 per cent (5 pounds per barrel) strong, nor used hot, but only warm, since a strong hot soda solution has a tendency to soften rubber. The more so is this the case, the more impure the rubber is made by addition of mineral admixtures.

Rubber hose should not be steamed, especially not the ordinary grades, but should be flushed with warm water only.

A precaution to be observed when passing hot water or soda solution through a rubber hose is to lay the hose straight when so doing, since if bent or "kinked" while warm, the rubber w

soften and conform permanently to this shape. A spiral bottle brush can be drawn through the hose with good results, and cold bisulphite of lime can be run through for disinfecting it. Rubber hose should be stored in a cold place, preferably kept wet or moist, and laid out straight upon a floor or wound in coils of large diameter.

Iron pipes, after cleaning, should be stained with a tannic acid solution. (See "Varnishing, Lacquering and Staining of Iron Vessels.")

REMOVAL OF WASTE PRODUCTS.

(See also "Utilization of By-Products.")

The waste products in a brewery are yeast, wet grains and spent hops.

YEAST.

Yeast in the cellars should not be allowed to remain upon the floors, as it will quickly form a resistant coating difficult tc remove, and should, therefore, be flushed or washed off as soon as deposited.

WET GRAINS.

Wet grains are very apt to sour, and should be removed from the premises immediately if no grain dryer is installed. (See "Grains.")

SPENT HOPS.

Spent hops from the hop jack should be removed as soon as possible, as they contain considerable albumen ("Trub," dregs or sediment from the wort) that is liable to putrefaction.

Spent hops are usually burned under the boilers. A German brewer uses his spent hops, after partial drying, as a bedding for his horses, and reports that on account of their aromatic odor they are well liked by the animals.

VARNISHING.

The varnishing of wooden vessels used in the brewery is done for the purpose of preventing the beer from coming in contact with the wood and thereby dissolving the extractive substances it usually contains, which would tend to impart to the beer a rank taste.

Another purpose of varnishing vessels is to prevent the beer *from* penetrating the pores of the wood, where it would [illegible]

or putrefy and infect, or detrimentally affect, the beer that would be subsequently contained.

The process of varnishing may be divided into the following manipulations:

1. The preparation of the varnish.
2. The preparation of the vessel and application of the varnish.
3. Precautions during the work.
4. Treatment after varnishing.

PREPARING THE VARNISH.

The preparation of the varnish requires some skill and is quite a tedious and lengthy operation, on account of which it is, perhaps, preferable to purchase the varnish from a reliable manufacturer.

A good brewers' varnish consists of from 3½ to 4 pounds of pure shellac dissolved in a gallon of alcohol. Formerly only grain or ethyl alcohol was used, but recently "Columbian Spirits," consisting of practically pure and deodorized wood or methyl alcohol has also come into use as a solvent.

Grain alcohol varnishes are much higher in price than those from wood alcohol, on account of which the latter are being used to some extent. But the former are considered superior by many brewers on account of their slower drying qualities, by which it is claimed a denser and more resisting coating is obtained. Others, however, prefer wood alcohol varnishes on the ground that they are more rapid in drying, and consequently shorten the time required for varnishing.

In making varnish, the solution of the shellac is readily accomplished by placing the vessel containing the alcohol and shellac in a warm place (about 80° to 100° F.) and occasionally agitating it to hasten solution. Care should be taken to keep this vessel closed to prevent evaporation of the alcohol.

Various admixtures of other gums have at times been advised, but experiments of this kind are not to be recommended, since it has been found that if shellac of a good quality is used the desired results are obtained, provided the varnish was properly applied.

Attention should be called to the fact that it is very poor economy to use cheaper and inferior makes of varnish since the value of the varnish, as compared to the value of its proper

services, is infinitesimally small, and the cost of labor to apply a poor and a good varnish is the same.

For composition and properties of shellac varnish see also "Varnish," under "Brewing Materials."

PREPARING THE VESSEL.

In the preparation of the vessel to be varnished the first manipulation necessary is to dry it, which is usually done by means of a charcoal stove placed inside. The varnish is then removed by scraping and sandpapering until a smooth surface is obtained, the vessel again heated for a short time, cooled off and the varnish applied with a brush.

Overheating the wood before varnishing is to be avoided, as it is then difficult to apply the varnish evenly. The temperature of the wood should be such as to allow the varnish from each stroke of the brush to unite with each former one and not to overlap it, which would occur if the varnish "set" immediately, due to overheating or to the varnish being too thick. This immediate setting would also cause the varnish merely to cling to the surface of the wood and not allow it to enter the pores.

In order easily to remove the old coating of varnish and thereby avoid the laborious manipulation of scraping, chemicals or "varnish removers" are sometimes used. These generally consist of a mixture of caustic soda and quicklime, with enough water to form a paste. This mixture is smeared upon the varnish and left there for a certain length of time until the varnish has softened to such a degree that it can be easily removed with a stiff brush and a spray of water from a hose. These varnish removers would be all that could be desired if, from a practical standpoint, it were possible to determine the exact time when the chemicals had penetrated the varnish only and not the wood underneath. The danger in using chemicals for removing varnish lies in the fact that the coating, even if well applied, is always more or less uneven, and that the thicker parts of the coating require a longer application than the thinner ones. This, with the usual occurrence that the remover is left on too long anyway, causes the chemical to enter the pores of the dry wood, which readily absorbs it and from which it can be removed *only by a* tedious method of soaking and subsequent drying of *the wood.* If the chemical has entered the wood and the new

varnish is applied over it, the chances are that it will work backward and remove, or at least soften this coating, the effect of which needs no further explanation.

When varnishing old vessels one coating may be sufficient, although it is advisable to apply two, since two thin coats are better than one thick one.

New vessels require three coats. The first one should be applied with the varnish rather thin, so as to allow it to penetrate the wood as deeply as possible. After the first coat the wood will be found to be rather rough on account of the fibers warping or rising, and it should, therefore, be sandpapered to smoothness.

The second coat should not be sandpapered too briskly, merely enough to smooth down the ridges, as otherwise the varnish would be rubbed off at the high places and the wood underneath exposed.

Each coating of varnish should be allowed to dry for at least forty-eight hours, and first coats on new vessels for twenty-four hours longer before the succeeding coat is applied.

At the expiration of 48 hours, after the last coat was applied a vessel that has been properly treated can be rubbed with a decoction of hops, with which a little yeast has been mixed, and within a few hours washed with water, after which it is ready to be put into service. It is hardly necessary to soak it with water where this treatment has been applied.

It may happen that the varnish turns white or grayish, which can usually be traced to the following causes: That the shellac used was of an inferior quality; that the wood of the vessel was green or was not thoroughly dry; that a coat of varnish was applied too soon, the under one not being dry; or that the vessel was filled with water or beer before the varnish had dried perfectly. See also "Varnish," under "Brewing Materials."

PRECAUTIONS DURING VARNISHING.

Besides the mechanical precautions above mentioned during varnishing there are two other and all-important ones to be observed, viz.: the prevention of dangerous results by an explosion, or the inhalation of the vapors by the workman.

The frequent accidents by explosion happening while varnishing casks, which are sometimes attended with loss of life or injuries to *workmen*, are generally due either to carelessness or

to lack of knowledge on the part of the workman or superintendent. They are caused by the vapors of the alcohol or other solvent of the varnish mixed with air and brought in contact with a flame. Vapors of alcohol, benzine, illuminating gas, etc., when pure, will burn only at their line of contact with the air, and a closed vat or barrel, when filled with these vapors only, would not be dangerous, in fact, the vapors would extinguish any flame suddenly immersed into them. The liability to explosion lies in the fact of these vapors being mixed with considerable quantities of air, forming a highly explosive mixture.

The means of preventing these explosions must be looked for in either of two methods—namely, in avoiding all possibility of any flame coming near these mixed vapors and air, or in keeping the amount of vapors in very small proportion to that of the air by means of draft or forced ventilation, as a trace of these vapors in a large volume of air is not explosive, but becomes so only when larger quantities are present.

One of the most common methods for illuminating the interior of casks, etc., during varnishing is by means of an incandescent electric light variously protected from breakage. But breaking may, and has, occurred, so this method cannot be considered very safe.

The second source of danger to the workman results from inhaling the vapors of the alcohol of the varnish. This has caused serious disablement, even death, and most of these detrimental or fatal results may be ascribed to the breathing of vapors from wood alcohol, especially if it was more or less impure.

Commercial wood alcohol contains substances of a more injurious character than the alcohol itself, principally acetone and aldehyde.

Grain or ethyl alcohol, owing to the manner of its production, is obtained in purer form, and its higher boiling point makes it easier to free from more volatile admixtures.

When a comparison is made between the effect of the vapors of the two alcohols, freed from all impurities, on the human system, it is found that grain alcohol simply intoxicates, and, if inhaled in large quantities, stupefies, leaving behind no serious after effects—at least, with ordinary care. Wood alcohol, on the other hand, has a more toxic influence, the vapors producing nausea and vomiting.

The methods and appliances in use for preventing the dangers above described are principally of three kinds, viz.: 1. To place the light, in form of an isolated lantern, etc., outside the cask and illuminating the inside through the manhole; 2. to supply the workman with a mask or hood, similar to a diver's helmet, and introduce fresh air through a hose leading to the helmet; and, 3, to ventilate the cask so that the amount of inflammable and injurious vapor is always below the danger line.

The first precaution removes the danger by explosion, but not the danger of poisoning the workman; the second protects the workman from deadly fumes, but does not prevent explosion, while the last guards against both contingencies. The second can, however, be easily made to cover both contingencies, as the cask can readily be ventilated by a branch from the air hose to the helmet. Ventilation of the cask has the further advantage of causing the varnish to dry more rapidly by removing the air saturated with the vapors of the alcohol.

ACCIDENTS.

If, despite all precautions, an accident should happen in varnishing—which is scarcely to be expected, however—the first attention should be given to the injured persons. If the man's clothes have caught fire those who appear first on the scene of the accident should not waste time by senseless lamentations, but be ready with active assistance. If the victim tries to run around he should be thrown to the ground by force, if necessary, and the fire smothered with blankets or clothing. If the person has suffered serious burns take him to a suitable place and apply a mixture of limewater and linseed oil, putting it on the burns and covering them afterward with cotton. In case of slighter injuries, dip cotton cloths in a strong solution of alum, or mix scraped Castile soap with water to a thick mush and spread on linen or cotton cloth, and apply to the burns until a physician can be had.

If the noxious gases have been inhaled the person should be undressed at once and cold water poured over him. Then lay him down on his face, turn him over carefully on the side, then back on the face, and so on back and forth. This should be done quietly but steadily about fifteen times a minute. The object *is this:* While lying on the face the chest of the ma

will be pressed by the weight of the body, which promotes exhalation; when he is turned on the side the pressure will be relieved and inhalation accelerated, and the noxious gases be thus thrown off.

PARAFFINING.

Paraffine, as a material for covering the inner surface of brewery vessels, has many advantages over shellac varnish. It is cheaper than shellac, it is easier and safer to handle, it is a perfectly neutral body, not easily affected by chemical compounds. Paraffine melts to a very thin fluid, which penetrates deep into the pores of the vessel and at the same time forms only a thin coating on the inner surface of the vessel.

The vessel is prepared for paraffining in the same way as for varnishing—that is, the old varnish is removed first and the vessel heated.

The best kind of paraffine to be used for coating brewery vessels is that which melts at 133° F. (45° R.). It is advisable to heat the dried vessels to be paraffined slowly to a higher temperature than for varnishing (about 190° F. or 70° R.). The paraffine is heated to about 176° to 194° F. (64° to 72° R.), but not higher, else it will spoil the brush. It is applied in the same manner as varnish. It is, therefore, best to use a thermometer for regulating the temperature of the paraffine, which may be heated on direct fire.

The operations of coating the inner surface of the vessel must be repeated as long as any paraffine is absorbed by the pores. Usually three or four coats are sufficient. The paraffined vessel is allowed to cool and the superfluous paraffine carefully removed. The vessel is soaked with water for a few days, flushed with warm water, not above 122° F. (40° R.), then cold water, after which it may be used.

Charles Buehler, in an address delivered on April 3, 1896, before the Brewmasters' Association of Pittsburg, pointed out the advantages of paraffining. He claimed that a paraffined vat is easier to keep clean and keeps longer than a varnished one. "If, for instance, we use one gallon of varnish for coating a fermenting vat, its cost amounts to about $3, while 10 pounds of paraffine at 8 cents a pound would be necessary for the accomplishment of the same purpose, a saving of $2.20 for each vat." (American Brewers' Review, 1897, p. 388.)

One of the causes why paraffining does not gain popularity with the brewers may be due to the appearance of the surface of paraffined vessels, which feels slippery and is of an unsightly gray color. These are signs of uncleanliness in varnished vessels, but, in case of paraffined vessels, do not indicate anything of that kind.

In case of paraffined vessels, as well as in varnished, the workmen cleaning them ought to be supplied with rubber boots in order to keep the film of paraffine on the inner surface intact.

VARNISHING AND STAINING IRON VESSELS.

It is an iron-clad rule that no surface in the brewery that comes in contact with wort or beer should be painted with a linseed oil and pigment paint. Vessels which are to hold those liquids are, therefore, either coated with a gum dissolved in a volatile solvent, or stained with a substance that forms an inert combination with the iron of iron vessels, if such are used.

Iron brew house vessels, such as the rice tub, mash tub, hop jack, surface cooler, beer tanks, also the iron part of Baudelot cooler and cooler pan, can be varnished with a shellac iron varnish; but as these vessels are used daily and their cleaning necessitates daily scrubbing and brushing, such varnished coatings must necessarily be frequently renewed, and varnishing is, therefore, impracticable. The method for protecting the surfaces of these iron vessels that has given the best results is to stain them with tannic acid, the combination being tannate of iron, a black, closely-adhering film, inert to wort and of great resistance to frictional cleaning.

The cheapest manner of obtaining this coating or stain is to make, in a new brewing outfit, a blind brew with a boiling decoction of about two pounds of hops (old, worthless hops) to the barrel of water, allowing this hot decoction to remain in each vessel for at least an hour. It goes without saying that these vessels should be first thoroughly cleaned with a steel brush and soda solution in order to remove any iron scale, rust, grease, etc.

Instead of a decoction of hops, a hot solution of commercial tannic acid will answer, but this is a more expensive method.

Cold-water tanks can be varnished with iron varnish, although this is not absolutely necessary if they are always kept filled *with water.*

Hot water tanks cannot well be varnished, as the boiling water has a destructive effect upon the varnish.

PITCHING.

The covering of surfaces with pitch has been treated under "Outfit of a Brewery," page 618. (See also "Pitch" under "Brewing Materials.")

PAINTING.

By painting is understood the covering of surfaces for protective as well as for ornamental purposes.

Paint differs from varnish in the fact that it consists of non-volatile linseed oil, in which some desired body or pigment has been suspended, while varnish consists of a volatile liquid, in which some gum or combination of gums is dissolved. When varnish dries the solvent evaporates and leaves the gums in a thin coating upon the surface. The drying of paint is caused by the oxidation of the linseed oil, by which it is transformed from a liquid into a thin, tough, elastic skin, which readily resists the action of the weather and also moderate friction.

Linseed oil varnishes consist of gums, etc., dissolved in linseed oil, and are really colorless paints.

MATERIALS.

Although the materials used in painting are of endless variety, the general basis for making them is linseed oil, while the pigments most commonly used are white and red lead, zinc white, oxide of iron, lampblack, yellow ochre and drying oil or driers.

Linseed oil is pressed from flaxseed and is used either as raw or boiled oil. To produce boiled oil, the raw oil is heated in contact with oxidizing agents, such as litharge, peroxide of manganese, borate of manganese, etc., and then has the property of producing a paint that will oxidize or "dry" more rapidly.

Linseed oil is subjected to much adulteration with mineral oils and other non-drying oils, which greatly impair or render it worthless.

Turpentine, popularly called "turps," is a volatile liquid obtained from the distillation of the sap of pine wood. Turpentine is also adulterated, generally with heavier products of petroleum distillation. Turpentine also possesses drying qualities, but to a much less degree than linseed oil.

Benzine is a product of the distillation of petroleum, and, as it evaporates completely, serves only to dilute the paint to which it is added.

Both turpentine and benzine are of practically no value except to dilute the paint, thereby lessening the amount of linseed oil and hastening the drying of the paint. They also give the paint a greater covering power, thus requiring a less number of coats, as by their removal by evaporation the amount of color or pigment is proportionally increased, and, in paint used upon wood for the first coat, they cause the paint to adhere better, as the diluted oil will sink deeper into the pores of the wood.

White lead is the corrosion product of metallic lead. It consists of a variable proportion of carbonate and hydroxide of lead with traces of moisture.

White lead comes into the market ground in linseed oil, and there is probably no constituent of paint that is more subject to adulteration. The substance generally used for this purpose is barium sulphate, or barytes, or "blanc fix," a cheap mineral that possesses the same color and almost the same weight, but is vastly inferior in covering power.

White lead, when used as a white paint, has the drawback that when subjected to sulphurous vapors, always more or less present in localities where soft coal is used, it soon becomes discolored or darkens. It also, in combination with linseed oil, soon loses its whiteness, turning yellowish in a short time.

Red lead, or oxide of lead, is similar in properties to white lead. It has found extended application for painting iron vessels, beams and structural ironwork generally.

Zinc white, or zinc oxide, made by the burning or oxidation of metallic zinc, has, in recent years, found considerable application in painting, especially as a white paint, since it is not affected by sulphur, and maintains its whiteness much longer than white lead. Zinc white is not nearly so poisonous as white lead, and is considered by some to possess a greater covering power and a greater carrying capacity for linseed oil.

Oxide of iron has found extended use for painting ironwork, the same as red lead. It is cheap in price, has a good covering power and is not influenced by atmospheric conditions.

Lampblack, or "soot," is too well known to require description. It is the color basis of most black paints or for darker

ing the shade of light ones. It comes into the market ground in oil, as it is difficult to mix it with oil on account of its floating, "greasy" properties.

Yellow ochre is an impure oxide of iron, and, on account of its covering power and cheapness, is used as a first coat or priming.

Other pigments are principally umber, chrome compounds, vermillion, verdigris, Prussian blue and ultramarine.

Driers. In order to hasten the drying or oxidizing property of paint, driers are added. These consist mostly of linseed oil boiled with, or to which has been added, such substances as dioxide or borate of manganese, litharge and sugar of lead. The addition of driers to paint is beneficial only in moderate amounts, and it does not follow that the more drier added, the faster the paint will dry; on the contrary, an excess retards drying.

Japan driers are practically the same as the above with the addition of shellac or other gums to give a body.

Black *Japan* is not a drier, but a solution of asphaltum in linseed oil varnish and is used for painting iron.

Driers should not be added to paints that dry readily without them, nor when painting surfaces that can be given sufficient time to dry. They should not be used in finishing or last coats of a light shade paint. They should be added to paint shortly before it is used.

MIXING PAINTS.

The belief that most of the ready-mixed paints upon the market are more or less adulterated has been greatly encouraged or even started by painters who, by mixing the paints themselves, derive an extra profit. There is no doubt that the raw materials, linseed oil, white lead, etc., are also adulterated to a very large extent, so that there is really little gained by this special mixing.

The whole secret in obtaining a good paint is the payment of the price asked for them. Mixed paints are sold all the way from 75 cents to $2.00 a gallon for ordinary kinds, and up to $4.00 per gallon for paints for special purposes, such as for brewery use. These figures speak for themselves.

It is therefore advisable to buy a paint from a reliable manufacturer and to use only the highest grades, since, considering the greater covering power, the greater durability, the small

proportionate cost of material to that of applying the paint, and lastly, the annoyance and disturbance of a painting operation, it is evident that the highest grade of paint cannot be too costly.

Ready-mixed paints are now sold for almost every purpose, so that the brewer need not fear obtaining an unsuitable paint. These paints are made for brickwork, ice machine condensers, refrigerating pipes, inside and outside wood and metal work, floor paint, etc., all compounded to give the best service for the purpose intended.

PREPARING THE SURFACES TO BE PAINTED.

The proper mixing of the paint ingredients and the application of paints to different surfaces is a subject concerning which there is such a variety and conflict of opinions, that only the essential and principal directions, such as have been generally accepted by painters, are given.

Preparation of the Surface.—This depends upon the nature of the material to be painted. The two main points, however, to be observed are, freedom from grease or such foreign substances as will prevent the paint from adhering to the surface, and the removal of loose particles of the old coat of paint that, if covered by the new paint, can fall or drop off and leave the surface exposed in places.

Grease can readily be removed from old paint by scrubbing with soap and alkalis, such as soda or potash lye, also by addition of ammonia, care being taken that these chemicals are rinsed off and the surface allowed to dry thoroughly.

Loose parts can be removed by scraping with a blunt instrument, like a putty knife, or with a steel brush, the ridges thus left being sandpapered to smoothness.

APPLYING THE PAINT.

Woodwork, such as wainscoting partitions, should be allowed to dry out for several weeks before painting, so as to prevent the formation of cracks in the paint caused by the contraction of the drying wood.

Before painting new wood, all rough places should be well sandpapered and all knots and resinous streaks should be first coated with shellac varnish and allowed to dry before paint is applied. Nail holes and other depressions in the wood should be filled out with putty, but this should be done only after the *first coat of paint* has become dry, because if applied upon th

unpainted wood the putty will soon become loose or drop out entirely. This also applies to window sash or wherever glass is held in a wooden frame with putty.

Iron surfaces should be scraped or brushed with a steel brush to remove any scale or rust, and then further cleaned of grease, etc., before painting. The popular belief that, since iron rust or oxide of iron is a constituent of some iron paints, the rust on the surface of iron need not be first removed before painting, is erroneous. It has been found that this rust, if considerable in amount, even if covered with paint, causes a further corrosion of the iron underneath.

Refrigerating Pipes and Brine Tanks.—The chief properties of a paint for pipes, etc., are adhesion, elasticity and conductivity. As the pipes are likely to be covered with heavy deposits of ice, the paint must adhere tightly, as they are subject to extreme temperatures, causing contraction and expansion, the paint must be elastic, and in order not to reduce their cooling capacity the paint should not be made from non-conducting pigments.

The first two properties can be obtained in a maximum degree by using a paint made from absolutely pure oil, applied over a thoroughly clean and smooth surface and giving sufficient time for drying, the coats being applied thin and well worked with the brush. The last property is obtained by using pigments of high heat conductivity. Lampblack, graphite, asbestos, etc., would be, therefore, poor pigments to use for this purpose, but, on the other hand, excellent ones for hot-water tanks, etc.

Tin roofs should not be painted until the surface of the tin is roughened or slightly corroded by rain or dew.

Shingles on roofs should never be painted as this would only hasten their decay by any moisture that might find its way underneath. Shingles can be stained with special preservative preparations now on the market for that purpose.

DIRECTIONS FOR PAINTING.

If ready-mixed paint is used the thick sediment found at the bottom should be thoroughly stirred up and this stirring continued at regular intervals, while painting until all the paint has been used, as, otherwise, at the beginning the painting will be done with the oil and at the end with the pigment, making an uneven job.

If the paint is bought ground in oil—that is, in thick paste form—it should be thinned with linseed oil as above.

The paint should be well spread—that is, rubbed with the brush in all directions until the surface appears dead or "dry," and the last stroke of the brush should be in the direction of the grain of the wood. This requires more labor, especially if the paint is thick or "rich" with linseed oil, than if the paint is thinned with turpentine or benzine, which makes the paint cover easily.

Another mistake may be made in daubing too much paint on a surface and then evening it out to a point where the paint will no longer drip or run down in streaks. This latter method requires much more paint, and it gives the painter an incentive to do such work if he furnishes the paint outside of his contract for the labor. There is, therefore, no better way to judge the ability of a painter than by the number of brushes he wears out in doing a job. The only place where this thinning and flowing is allowable is when painting plastered walls, as it is there desired that the paint shall penetrate and color the plaster as far as possible, so that in the event of scratching or chipping the white plaster underneath will not show.

The priming, or first coat, on new wood surfaces should also be thinned somewhat, but never the second and subsequent ones.

Painting should not be done out of doors in damp or rainy weather, or when the thermometer registers below 50° F. No painting should be done in excessively hot or dusty weather.

The usual method of painting new work includes three coats only, one priming coat and two finishing coats, and the better and thinner the paint is brushed out, the greater will be the durability and the better the appearance of the work. These three coats should be of practically the same shade, although some painters prefer each succeeding coat to be somewhat lighter or darker in shade, so that it can be readily seen when the surface is covered, and "skipping" or overlooking of parts of surface prevented.

Each coat should be thoroughly dry before another is applied over it. Under ordinary conditions this drying requires from five days to a week. This precaution is not generally observed, however, the usual test being to consider paint dry the *moment it no longer* "rubs off" when touched by the hand.

[redacted]

If it is desired to paint a surface that has previously received one or more coats of whitewash, this whitewash must be completely removed. This is done by wetting the surface with water, scraping with a blunt chisel or putty knife, brushing with a stiff brush and allowing the surface to dry.

OIL FINISHING OR VARNISHING.

Many hard woods, such as oak, show a handsome grain surface and are therefore covered with a colorless, transparent coating, consisting of either boiled linseed oil or linseed oil varnish, both applied hot. For interior work, such as for the outside of fermenting, storage vats or chip casks, this treatment has proved of excellent service and is extensively used in breweries. It can be applied after the interior of the tubs have been varnished with shellac and the wood is still warm. The iron hoops are, after such treatment, usually painted with ordinary pigment paint.

Caution.—When wooden boards, brewery tubs, beams, girders, etc., are still in a somewhat moist condition they should not be painted or varnished (with shellac or other varnish) on all sides, as they would be subject to dry rot. This is especially the case if this moisture is due to the original sap of the wood.

ENAMEL PAINTS.

Enamel paints have of late found extended application in breweries. They consist generally of a mixture of white lead and zinc oxide—the white enamels of zinc oxide alone—mixed with varnish, usually a Dammar varnish, instead of linseed oil, as in ordinary paint.

The advantage of these enamels is that they furnish a harder, more glossy surface, which are therefore more readily kept clean. They are, however, more difficult to apply than paint, on account of their viscous consistency, and are used generally as finishing coats.

The usual method of applying them is to paint the surface with two coats of ordinary paint of the same shade, in the usual manner, stopping up holes, etc., with putty of the same shade, and, when dry, finishing with two coats of enamel paint. Over surfaces already painted, one coat of primary paint may *often be found* sufficient.

CARE OF BRUSHES.

When painting or varnishing is completed the brushes should be washed with turpentine or benzine. When the painting operation is interrupted for several days in order to allow a coat to dry, the paint brushes can be kept soft and ready for use if suspended by their handles in water, but should not be allowed to rest upon their bristles. Before using again they should be thoroughly brushed over a clean board.

This treatment does not apply to varnish brushes, as they will, even if brushed out as above, cause the newly-varnished surface to be covered with minute blisters. Varnish brushes should be dipped into the same varnish used, contained in a can or small covered receptacle.

WHITEWASHING AND CALCIMINING.

Where it is not desired to use paint on account of the cost, or where surfaces are more or less moist, a coating of whitewash or calcimine can be applied instead of paint.

Whitewash, or milk of lime, is used when rough surfaces, such as brick walls, are to be covered. It is cheap, easily prepared and easily applied; in fact, machines for whitewashing are now on the market. These consist of a pump, a hose and a spraying nozzle. The whitewash is contained in a barrel or other vessel from which it is drawn by one stroke into the pump and by the other stroke forced through the hose and nozzle from which it is thrown in a fine spray against the surface. When covering broken or uneven surfaces, such as open joist ceilings, these machines cover in but a fraction of the time required to do so by brush, and furnish a better-appearing job.

A good, durable whitewash can be prepared as follows: Slake one-half bushel of freshly-burned lime with hot water in a covered box or receptacle, so as to keep in the steam, and add 7 pounds of ordinary salt, previously dissolved in hot water. Then add 5 gallons of hot water, stir well and pass the mixture through a sieve to remove the coarse particles. This whitewash should be applied while hot. The addition of salt is to bind the whitewash better when dry.

Before applying whitewash the surfaces should be well scraped with a blunt chisel or putty knife to remove loose particles or scales of old whitewash coating. New brick walls can be *prepared by brushing* with a stiff brush to remove sand, etc.

The former coating of whitewash on a surface can be more thoroughly removed if it is well moistened with water. The scraping operation especially is greatly facilitated thereby.

All surfaces in the brewery can be whitewashed except ceilings over open vessels, as there is danger of the whitewash scaling off and falling into the vessels. Such ceilings should be painted.

Calcimining differs from whitewashing in that it furnishes a smoother surface, and is, on that account, usually employed for covering hard-finished walls, especially when different tints or colors are desired for ornamental purposes.

Calcimine differs from whitewash in that whiting (Spanish or Paris white) is used instead of slaked lime, with the further addition of glue to prevent rubbing off.

If the surface is new it should first be "sized" with a solution of glue in water, so as to render the surface non-absorbent, as otherwise the calcimine, if applied over a surface of uneven porosity, would dry in patches of different shades of color. When mixing colors to calcimine it should be taken in consideration that the color, when dry on the surface, will be lighter in shade and more brilliant than it was when mixed in the pail.

If a white color for calcimine or for whitewash is desired a very small amount of blue color, such as ultramarine blue, should be added, enough to give a very slight bluish shade to the mixtures while wet. This, if applied, will dry out a brilliant white, the blue entirely disappearing unless too much of it was used.

Hydraulic cement washes have of late also come into use. These are nothing more than calcimine, to which a form of hydraulic or Portland cement has been added. These washes or coatings go by different names and require a special method of application, differing with each one. They have been found, as a general rule, to give excellent results, and, although higher in cost than self-prepared whitewash or calcimine, are to be recommended on account of their uniform composition and generally satisfactory results obtained.

It should always be remembered that the cost of materials, be it paint, varnish, whitewash, etc., is always but a small item compared with the cost of the labor to apply it and the annoyance if a poor job has resulted.

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UTILIZATION OF THE BY-PRODUCTS OF THE BREWERY.

The important by-products of the brewery and malt house are screenings, skimmings, malt sprouts, underdough, spent grains, spent hops, dregs ("Trub"), yeast, carbonic acid.

SCREENINGS AND SKIMMINGS.

If the screenings from the barley cleaners contain much dust, this is screened out, and the undersized, light and broken kernels, of which the screenings are composed, are sold as chicken or cattle feed, after being mixed with the floaters from the steep tank which are either gathered by skimmers or carried from the steep tank by a current of steep water through an overflow pipe (see "Malt House Outfit") at the top of the tank into a tank provided with a perforated bottom. This wet grain is dried on perforated plates or in a regular kiln.

MALT SPROUTS.

Malt sprouts contain a very large amount of nutritive substance, and may be considered a concentrated foodstuff for cattle. They are especially valuable as a feed for milch cows on acount of the large amount of easily assimilable nitrogenous substances.

Thausing gives the following analysis of ten samples of sprouts:

	Max.	Min.	Aver.
Moisture	15.60	3.74	10.09
Nitrogenous substances	28.94	20.21	24.18
Fat	3.0	1.43	2.10
Nitrogen free substances	46.0	37.06	42.11
Wood fiber	18.50	10.61	14.33
Ash	9.7	5.10	7.19

The sprouts should be mixed with other feed, like hay, as they are too concentrated a food to be taken alone, and also because they are apt to be refused on account of the bitter taste, to which

cattle, however, gradually become accustomed. The value of malt sprouts, as feed, is calculated, on the strength of the analysis, to be about five times as great as that of hay. They are not, however, paid for to the full of their value.

If they cannot be utilized for feeding purposes they may serve as an excellent fertilizer on account of their nitrogenous components, and the ash which is almost entirely made up of phosphoric acid and potash.

The amount of malt sprouts is about 3 per cent of the weight of the malt produced.

BREWERS' GRAINS.

Brewers' grains are now recognized as a valuable cattle feed, and are especially appreciated in this respect in Germany, to which country large amounts of the grains from American breweries find their way in a dried condition.

Settegast (Fütterungslehre, Breslau) says that brewers' grains take the first place among the feed by-products of agricultural industries, considering their wholesomeness, especially in the case of cattle and swine. They affect to a high degree the flow of milk, on which account they deserve preference for feeding milch stock, and one need not hesitate to cover as much as half of the feed demand by brewers' grains.

In a report of the New Jersey Agricultural Experiment Station, 1893, relating the results of feeding experiments with horses, E. B. and Louis A. Voorhees state that "by actual trial a pound of dried brewers' grains was shown to be quite as useful as a pound of oats in a ration for workhorses. A comparison of the composition of the feeds indicates that the reason for this result lies in the fact that the dried brewers' grains furnish more of the valuable digestible nutrients than the oats. . . . The substitution of dried brewers' grains for oats resulted not only in a maintenance of the weight of the animals under equivalent work but in a saving of 4.9 cents per day per horse, or 25 per cent of the cost of the ration." Dried brewers' grains, they say, at $2[illegible] a ton would be as cheap a feed as oats at 36 cents a bushel.

Such opinions leave no room for doubt as to the value of brewers' grains, and $10 a ton for the dried product seems to cover only about one-half their intrinsic value.

The brewers' grains as they are discharged from the mash-tun are also fit food for cattle in the wet condition in which they

contain from 75 to 81 per cent of water. On account of this high percentage of moisture they are liable to fermentation and putrefaction, in which state they are no longer available for feeding purposes. They cannot be kept for any length of time in this condition, and experiments at ensilage, that is, storing them packed away in bulk, mixed with some salt, have not proven successful, as they have been known to sour quite frequently.

If pressed they will keep somewhat longer in ensilage. Experiments made as between the nutritive value of wet and dried grains have shown that the digestibility is but slightly impaired by the drying process, and little differences in milk flow will follow the substitution of the dried grains for the wet.

Dried grains at $15 a ton are equivalent to moist grains at from 10 to 11 cents per bushel. One pound of dried grains contains on an average as much nutriment as four pounds of moist grains.

RESULTS WITH GRAINS DRIERS.

Drying grains is now done regularly in some of our largest brewing plants, and the following information can be given from tests made and figures obtained from a grains drying expert:

A machine with a capacity of 1,500 bushels dry mash per day, floor space 5 feet 2 inches wide by 14 feet high by 22 feet 8 inches long, price $3,500. Power to run, 8 horsepower, took one-quarter to one-third pounds of coal to produce one pound dry grains containing 6 per cent moisture, using new steam made for the purpose specially. Where exhaust steam from a large plant is used this expense is considerably reduced; one man can attend to three machines when doing nothing else.

Steam pressure in upper drums, 10 pounds exhaust steam, or 10 pounds live steam reduced.

In lower drums, full boiler pressure in stirrers, upper stirrers 40 revolutions, lower stirrers 10 revolutions.

One pound dry grains = about four and one-half pounds wet, on an average.

One pound dry grains = about four pounds dry mash (material).

In large plants using this dryer the following was found:

One brewery dries wet grains from 56,000 pounds mash in 24 hours regularly.

Another brewery on a trial run dried 24,800 pounds mash

nine hours, but this amount is not advisable for regular operation. Power, 8 to 10 horsepower to run when properly fed, but there should be at least a 15-horsepower capacity of engine, as it has happened that a man filled the machine too full, and it then would require increased power.

A third brewery dries grains from 15,500 lbs. mash in 7½ hours, using power and steam to the value of $2 for that amount. This is figured on a basis of a cost of 10 cents per 1,000 pounds of water evaporated. These 15,500 pounds of mash give 3,800 pounds dry grains. Power to run machine about nine horsepower. They use 13 horsepower, but this includes power to run the blower for the dry grains. The dividing price for wet grains is $1.50 per ton. When the market is higher they sell grains wet, if lower they run the machines.

At a fourth brewery a test was made on an eight-hour run, with steam at 9½ cents per 1,000 pounds water evaporated.

Steam used in drying, 5,950 pounds	$ .47
Steam used in power, 3,295 pounds	.26
Labor, eight hours	1.17
	$1.90

It thus cost $1.90 to produce 4,000 pounds of dry grains. In this plant they used 13¾ indicated horsepower to operate. This included power necessary to convey the wet grains across an alley to the dryer, and operate a machine for packing the dry grains in sacks. The machine alone used 9 to 10 horsepower.

Brewery No. 1 dries wet grains from 2,333 pounds dry mash (material) per hour.

Brewery No. 2 dries wet grains from 2,755 pounds dry mash (material) per hour. (Crowding machine.)

Brewery No. 3 dries wet grains from 2,214 pounds dry mash (material) per hour.

Brewery No. 4 produces 500 bushels dry grains = about 2,000 pounds dry mash (material).

Wet grains weigh 60 to 65 pounds per bushel, dry grains 25 to 30 pounds per bushel. It takes 45 minutes to run them through the machine.

The higher percentage of protein or albuminoids contained in American grains, as compared with German, is due to the fact that practically all of the albumen of unmalted cereals, which are used in America to the amount of about 25 to 40 per cent,

passes into the grains, whereas of the albumen contained in malt, **about one-half** is dissolved during mashing.

ANALYSES OF BREWERS' GRAINS.

	Water.	Crude Fat (Heat Producer).	Crude Fiber.	Crude Protein (Flesh Producer).	Crude Ash (Bone Producer).	Carbohydrates (Heat and Fat Producer).	When Analyzed.	Analyzed By.
American dried grains—average of 8 samples..	9.50	6.06	13.82	21.53	3.82	45.00	1893	New Jersey Exp. Station.
American dried grains—average of 50 samples.	9.57	7.48	15.44	29.06	2.89	35.58	1890 to 1901	Wahl and Henius.
Maximum..............	13 50	9.78	17.36	41.65	3.20	61.25		..
Minimum...............	0	6.78	10.83	15.02	2.04	30.73		..
American grains from 50% malt and 50% grits	10.00	7.92	13.49	33.98	2.68	31.93		..
German dried grains—average sample.......	10.21	9.80	12.75	22.62	4.66	39 87		
German moist grains—average sample.......	80.37	0.99	3.43	4.56	0.97	9.09		Behrend

RELATIVE AMOUNTS OF BREWING MATERIALS AND WET GRAINS.

The amount of wet grains obtained from a certain amount of material employed in a brew varies somewhat, but is on the average about 16 per cent higher than the weight of the brewing materials.

In two different breweries the following tests were made by Wahl and Henius:

	Brewery I.	Brewery II
Materials used—cleaned malt........	6,200	7,638
Materials used—grits	6,200	7,500
Total materials	12,400	15,138
Wet grains	15,710	16,850
Increase	26.7%	11%
Moisture in grains	81.2%	78.6%
Commercial dry grains (with 6 per cent moisture).................	3,142	3,805
100 lbs. material gave, dry grains....	25 1/3 lbs.	25 1/4 lbs

The following table gives the amounts of wet grains actually obtained from the corresponding amounts of brewing material and the increase in per cent:

Pounds of material used in breweries.	Pounds of wet grains received of breweries.	Percentage showing increase of weight of grains over material.
551,345	642,600	16.55
489,465	556,550	13.71
488,830	553,170	13.16
440,865	480,090	8.09
573,675	629,960	9.81
465,510	546,460	17.39
397,990	476,730	19.80
497,795	603,510	21.24
531,420	610,760	14.93
524,440	607,450	11.58
492,090	598,130	21.55
458,025	520,880	13.72
536,600	629,880	17.38
488,425	566,150	15.90
480,770	565,660	17.66
528,725	617,630	16.82
Total..7,945,970	9,205,610	*15.85

*Average increase per cent.

In another test made the amount of dried grains obtained from 4,400 pounds of grits and 4,400 pounds of malt was 2,017 pounds of dried grains with 5.92 per cent moisture, or about 23 per cent of dried grains. (See G. Thévenot, Drying of Brewers' Grains, American Brewers' Review, IX, page 1.)

UNDERDOUGH.

After removing the grains, the underdough should be taken out as soon as the mash-tun is properly cooled, and mixed with the grains.

DREGS ("TRUB OR SEDIMENT").

The substance remaining in the sediment bags contains a large quantity of protein. Its proper place after draining the wort from the dregs ("Trub") is in the grains box. It should preferably be thrown into the mash-tun before the grains are removed, so as to insure proper mixing.

SPENT HOPS.

There seems to be no value attached to spent hops, properly *sparged.* They contain some nutrient substances, but not in suffi-

cient quantities to warrant drying them. Cattle do not take kindly to them on account of their bitter taste They have been used with good results, after drying, for horse-bedding, and seem to be preferred by the animals to straw. If not used otherwise they should be disposed of under the boiler as quickly as possible.

UTILIZATION OF WASTE YEAST.

Considering that yeast during the process of fermentation, while growing in the wort, takes up such valuable ingredients from the wort as phosphates of potash and other mineral substances, and the amides and peptones of the wort, with which it sustains itself and builds up the body of its progeny, it is rather strange that a substance containing such valuable ingredients should have been allowed to run to waste so long. The crop of yeast that is returned to the brewer during and after the principal fermentation is much larger than the quantity which is added to the wort in the first instance to start fermentation. Allowing for variations due to favorable or unfavorable conditions of growth, it may be assumed that the quantity of yeast which is allowed to run to waste in the brewery will reach, generally speaking, from one to two pounds per barrel of beer brewed.

With a view of recovering the many valuable substances that the yeast contains and making them serviceable for practical uses, R. Wahl and M. Henius of Chicago, during the last ten years, jointly conducted a number of experiments which culminated in the successful extraction of the yeast, ridding it of those foreign substances which impart to the extract a bad flavor or otherwise deteriorate the product. The process consists in washing the yeast with water, heating the cleaned yeast, rupturing the membranes, and bringing into solution the valuable mineral and albuminoid substances of which the protoplasm of the yeast is mainly built up, separating the membranes from the soluble parts by filtration, decantation or otherwise, and condensing the extract to a syrupy or solid form.

Analyses of this extract show that it contains essentially the same substances that are found in meat extract.

Besides serving as a tonic in the place of extract of beef, the new vegetable extract from yeast can be employed with good results in the brewery for nourishing yeast, as it contains the very products that the yeast requires for food, since it is composed of the identical albuminoids and mineral substances which the yeast consumes

This new yeast product (patented June 4, 1895) can be easily evaporated to a perfectly dry state, in which it is an easily powdered, lustrous mass of a light brown color. This mass readily dissolves in hot water, leaving it perfectly clear, and the solid products as well as the hot aqueous solution have the odor and taste of a freshly prepared extract of meat.

Following is a comparative statement of analyses of the respective substances:

	Liebig's Ex. of Beef.	Armour Ex. of Beef.	W. & B.'s Extract of Yeast.
Moisture	15.26	15.97	15.32
Mineral substances	23.51	29.36	25.77
Of which phosphoric acid and potash	(72.5%)	(52%)	(65%)
Albumoses	2.01	1.75	5.5
Peptones	8.06	5.13	15.0
Meat bases	29.32	41.12	21.3

A comparison of these analyses shows that yeast extract contains a higher quantity of the most valuable, readily digestible and nutrient albumoses and peptones, on which the importance of the extracts depend, than even meat extracts. (See Allen, Commercial Organic Analysis, 1898, Vol. IV, page 310.)

UTILIZATION OF CARBONIC ACID.

The amount of carbonic acid escaping from the fermenting vats of a brewery during the principal fermentation is very large. For every pound of sugar that ferments one-half pound of carbonic acid is formed. The wort or beer is able to retain only a small fraction of the carbonic acid generated, about three-quarters of a pound per barrel, the remainder escaping. Of the sugar contained in an ordinary wort about 7 per cent ferments, or about 17½ pounds per barrel, producing 8¾ pounds carbonic acid, 8 pounds of which escape, or, for every 100 barrels of beer brewed there is a loss of 800 pounds of carbonic acid.

Of late this carbonic acid has been successfully collected in some large brewery plants and is employed for charging the beer of the brewery in its final stages with carbonic acid, or, it is purified and compressed into drums and put on the market for charging beer and other beverages, displacing the liquid carbonic acid produced from other sources, mainly marble dust and sulphuric acid. If properly purified it certainly deserves preference

over carbonic acid from chemicals, and is readily distinguishable from such by the mild, "clean" taste of the charged beverage, whereas water charged with marble dust, gas has a peculiar flavor not relished by a sensitive palate.

In order to collect the gas the fermenting vats are provided with hoods. The carbonic acid escapes through a kind of parachute, and is conveyed by means of a pipe that connects with all the hoods, to the purifier, where the gas is washed by means of water and sulphuric acid, which remove all the aromatic ingredients like ethereal oils. It is then passed through a solution of permanganate of potash and carbonate of soda, to remove all traces of acid, and then dried and compressed to a liquid, if desired. In most cases, however, the gas is withdrawn from closed fermenters, washed and compressed.

THE BOTTLING DEPARTMENT OF A MODERN BREWERY.

There are few departments that have received less special attention by brewers than that concerned with the bottling of their product. Formerly this department was considered by most brewers, especially by those having smaller plants, as a necessary evil, and was often installed simply because the brewer's competitor had done so, or because a few good customers had demanded bottle beer, rather than because there was any hope of making this department self-sustaining or a source of profit to the brewery.

This condition has changed, as the demand for bottle beer in private families, hotels, railroad trains, and even in saloons is steadily on the increase, and a first-class bottling department is considered a necessity with many a modern brewery plant.

When special attention was given this department it was found that the old shed used as a bottle shop, with its meager appliances, would no longer answer, and the deficit in the department due to breakage and loss of bottles and boxes, and the loss of time of the men by "soldiering" or otherwise (because it did not pay to employ a competent special foreman to keep track of them), could be avoided by improving and properly managing the department. In fact, there are to-day a considerable number of brewers who reckon on their bottle trade returns as no small portion of their yearly revenue.

To accomplish this requires economical arrangement and the most improved appliances and machinery.

REQUIREMENTS OF BOTTLE-SHOP MACHINERY.

The requirements of bottle-shop machinery are of the most *rigid order.* They must operate not only economically, but very *thoroughly.* For instance, a soaking device that does not soak

a bottle properly does not soak it at all; that is, the bottle must be run through again, and the time required in handling it during the first operation is time practically wasted. A defect becomes still more costly in the pasteurizing or steaming tank, for if it does not furnish an even, gradual rise or fall of temperature it is likely to cause breakage of bottles and loss of contents. What is still more detrimental is to not give an even temperature throughout the tank, so that some bottles never reach the final pasteurizing temperatures. This may result in their spoiling afterward, while in the possession of the consumer, which may mean not only loss of time and material, but possibly loss of trade besides. Similar defects are liable to occur at nearly every stage of the process, and will be detailed more fully under the separate descriptions of the machinery and devices employed at each individual step of the work.

ARRANGEMENT OF BOTTLE SHOP.

One of the first points to be considered is the general arrangement, which is as important in bottle shops as in the brew house and cellars. The arrangement should be such that there is absolutely no useless or double handling of any bottle or case, and benches or machines should be so placed in relation to each other that they form an unbroken line from the dirty returned bottle to the capped and labeled bottle in the case for delivery.

The bottles should first be placed in the soaking device (tank or wheel), from which the man should, when all labels, tin foil, etc., are removed, place them directly on the rack at his side and between him and the bottle-cleaning machine. From here the man at the machine takes them, runs them through the machine and places the rack on a bench at the opposite side of the machine, where a boy takes out the bottles, examines them as to cleanliness and places them on the adjacent rack next to the man operating the filling machine. This operator places the empty bottles in the machine with one hand and removes filled ones with the other, placing them on a bench, where they are either closed and examined, if patent stopper bottles, or taken by the man who operates the stopper machine. When closed, they are again placed on a bench, where they are likewise examined, clamped or wired, and put in a crate previous to going into the pasteurizing tank. After being steamed they are labeled and capped with tin foil, etc.

It is important always to observe the same economy of handling, each bottle going from hand to hand, and avoiding the laborious operation, frequently necessary in poorly-arranged plants, of stacking the bottles one by one on a truck and hauling or carrying them to the next machine or operator, where they are again unloaded and placed ready for use.

It may be of importance to call attention to a circumstance occasionally met with and which applies to the operation of machinery of any kind. It will happen that a certain machine or appliance has been found fault with, or, in some instances, totally discarded, because it would not do the work claimed for it, while in other plants the same style of machine seemed to work to perfection and gave the best satisfaction. In such instances the fault can be usually located either in a mechanical defect in some minor part of the machine, such as in a valve or cock, etc., or, which is more often the case, in improper physical conditions in the operation of the machine, such as pressures or temperatures of water, air or steam. An example of this would be, for instance, if in bottle-washing machines using shot, the rinsing stream of water did not discharge with sufficient force to dislodge the shot, allowing it to clog the neck of the bottle and necessitating the shaking of each bottle for its removal, or if, in back-pressure filling machines, there was too little difference between the initial and the back pressure, the beer would run too slowly, and in both instances make the machine quite worthless from the point of view of economy. Neither of the defects mentioned would be due to the construction of the machine, but to the handling of it. Nevertheless, the machine would in all probability get the blame for it.

BOTTLE SOAKING.

The object of soaking bottles is either to dissolve the dirt, sediment, etc., contained in them, or to soften these sufficiently to be easily removed by the washing machine, and further to wet the labels to such an extent that they either drop off the bottles or are easily taken off afterward.

The substances to be removed from beer bottles by soaking and washing usually consist of dried beer remnants, which invariably contain countless numbers of wild yeasts and bacteria that have found their way into the bottles, and there multiply rapidly, the beer remnants furnishing them bountiful nourishment.

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The soaking, then, becomes a most important part of the bottling process, as it may happen that the spores formed by these wild yeasts, etc., are not completely removed during the soaking and washing, even though the bottles may appear clean.

These spores possess much greater vitality and resistance than their parent cells, and are not always destroyed at the temperature to which beer is subjected during the pasteurization process, hence they may survive the steaming process, and in this case cause fermentation, cloudiness, abnormal taste, etc.

It also occasionally happens that bottles, especially patent-stopper bottles, find their way back to the bottle shop containing remnants of varnish, oil, chemicals, etc., in which case it is advisable to throw them away rather than to attempt to soak or clean them.

In order to hasten the soaking or softening process, soda or other alkalis are added to the water. This addition has the further action of softening or dissolving substances that would not be affected at all, or very slowly, by water alone, such as fats and oils and some of the albuminous substances.

BOTTLE-SOAKING TANKS.

The most common bottle-soaking device in use is the soaking vat or tank, consisting of a square or rectangular board receptacle, or sometimes of half of an old chip cask, in which the bottles are simply submerged in a soda solution and left there for a certain length of time. This method, however, on account of the bottles being knocked about and against each other a good deal while floating or sinking, causes considerable breakage, and a large proportion of the bottles sink before being completely filled, retaining air, which, upon the bottles settling on their sides, is unable to escape and forms an air bubble at their upper part, preventing the soaking solution taking effect at that place.

To obviate this annoyance the bottles are sometimes placed or set in the empty tank, neck up, and the soaking solution poured or run in on them. This, of course, prevents the formation of any air bubbles, but requires considerably more labor and time in handling the bottles. Furthermore, it is difficult to place a second tier of bottles upon the lower one without some intervening board or grating.

Soaking Tanks with Inclined Bottoms.—This drawback can be practically overcome, however, by constructing the bottom

on an incline or slant; or, as is generally done, high at the center and sloping to the sides of the tank. In this construction the tank can be filled with slanting layers of bottles without any intervening partitions or supports. Care should, however, be taken to have each layer consist of bottles of the same size only, as mixing together pints and quarts in the same layer would soon disrupt the uniformity of the whole arrangement. By running the soaking solution on the bottles in this position there will be no likelihood of their not filling completely.

Portable Soaking Tanks.—A portable soaking tank which possesses novel features is now on the market. It is similar in general shape to ordinary tanks, but is mounted upon swivel castors, and in addition to a large outlet for the soaking solution has a smaller one that can be so adjusted that the solution will escape no faster than the bottles are taken out. The top layer is thus always visible to the operator, and any broken bottles can be handled with the proper caution, which is not always the case in other tanks, where the operator, to take out the bottles, must plunge his hand below the surface, often encountering broken glass and suffering serious cuts. The tank also has movable racks or supports placed in the bottom so that the bottles can be stacked in an inclined position, allowing each to be completely filled.

The principal advantage, however, claimed for this soaking tank is its portable character, which enables a boy to move the tank, when filled with bottles and solution, from place to place quite easily, whereby bottles at different points in the shop can be gathered up in much less time than would be necessary to bring them to a stationary tank. A tank filled with unusually dirty bottles requiring longer soaking can be moved aside and out of the way, or if it is desired the tank can be used as a stationary one, and can even find use as a truck for moving cases about, etc.

Compartment Soaking Tanks.—In another soaking device the tank is divided into compartments. This tank is supplied with tin-foil remover and washing machines, conveniently placed, also a bottle conveyor. The system is operated as follows: The bottles are placed in the compartments in the evening and allowed to soak all night. In the morning they are taken from the tanks and placed on the conveyor, by which they are carried to the operators, who stand at the washing tank. They take the bot-

tles from the conveyor and place them on the washing machines (and when necessary on the tin-foil remover) and finally deposit them on the rinsers. By this method considerable useless handling and carrying around of bottles is avoided. It furthermore offers a check on the workmen, as one glance at the conveyor shows the foreman whether the bottles are being put on or taken off with the usual rapidity.

SOAKING SOLUTIONS.

The strength of the solution best adapted for soaking bottles in the different styles of tanks is one that contains about 5 pounds of soda to the barrel of water, making it approximately 2 per cent strong. This strength is sufficient to soak the bottles thoroughly, and not so strong as to injure the hands of the workmen. As quite a few bottlers are guided more or less by guess work in making up their soaking solutions, the following instructions will help make the proper solutions and keep them uniform in strength. As most soaking tanks are square or rectangular, to find the number of barrels they contain, divide contents in cubic feet, that is, the length in feet $\times$ width in feet $\times$ depth in feet, by 4 (strictly, 4.144). This gives barrels, and multiplied by 5 gives the number of pounds of soda to be dissolved. The temperature of the soaking solution should be from 110° to 120° F. Since the introduction of soaking wheels and such devices where the bottles are not handled while wet with the solution, caustic soda has found use, being a stronger alkali, and the solution used warmer (150° F.).

BOTTLE-SOAKING WHEELS AND MACHINES.

Soaking wheels are gradually coming more into use, as they do away with considerable of the labor connected with a soaking tank. They furthermore shorten the time necessary to soak a bottle, as at each revolution every bottle is filled and emptied of its contents of soaking solution. This flowing in and out of the liquid not only causes friction against the inner walls of the bottle, which in itself hastens the cleaning process, but allows a fresh quantity of strong solution to act on the bottle at each revolution. In a soaking tank the bottles are at rest and the same volume of solution remains in the bottle during the whole soaking period. If the bottles stand upright, and contain a considerable crust of dried-up beer, which often happens in bottles returned from shipments that have been out for a

long time, the complete soaking may possibly be retarded, since the soaking solution, acting upon this sediment, dissolves part of it and becomes weaker at the line of contact, and, therefore, being specifically heavier, may form an inert layer and prevent the further action of the stronger solution above it.

Another time-saving feature of a soaking wheel is that the bottles can be left in the wheel as long as desired, enabling very dirty bottles to remain longer in the wheel without delaying those requiring only a shorter soaking. The latter generally represent by far the larger part of the total number of bottles treated.

Another advantage of soaking wheels is in the fact that the soaking solution can be made very much stronger, there being nothing about the wheel to be injured by it, and there is less occasion for the solution to affect the hands of the workmen, and in some the bottles are not handled from the time they are put in the wheel, until discharged in pure water. Furthermore, the amount of soaking solution in the tank being so much larger in proportion to the amount in the bottles, it can be used much longer before needing replacing or strengthening, and can be used again and again until it becomes weak, thus saving soda and time of making up solution. Bottles in very bad condition may be left in the wheel while others are being charged and uncharged, thus saving time.

Soaking wheels have a large daily capacity and are specially suitable for use in larger bottling plants.

Gravity Soaking Wheel.—A soaking wheel of simple and inexpensive construction now on the market consists of an iron wheel hung in a wooden tank containing the soaking solution. The bottles are placed on the wheel in iron pockets or holders with their mouths standing outward. By properly placing the bottles on one side and taking them off at the other side, thus overbalancing one side of the wheel, it revolves without power. The pockets are so placed that the bottles enter the soaking solution with their necks upward, thus filling, while they leave it in the reversed position and empty their contents automatically. The pockets are adjustable, so that different sizes and shapes of bottles can be inserted.

Compartment Soaking Wheel.—Another style of soaking wheel contains compartments into which the bottles are placed while being soaked. This wheel in construction consists of

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a wheel-shaped device, having pockets at its outer circumference. It is mounted on the top rim of a wooden tank, containing soda solution, thus causing the lower half of the wheel to run through the solution. The pockets are inclined so that the bottles may be put in while the wheel is in motion, and that they will automatically discharge themselves at the proper time. A sheet iron apron prevents the discharge from taking place on the downward movement of the pockets. At the back of the pockets are bars that hold the bottles in place while permitting them to fill and empty freely. The bottles alternately fill and empty during each revolution of the wheel, causing a vigorous cleansing action.

Steel Plate Soaking Device.—Another soaking device, similar in operation to the wheel, consists of a series of perforated steel plates, connected by two endless chains, the whole running over two pulleys or wheels placed at either end of a tank. The bottles are inserted into the holes in the plates, where they are clamped and carried through the solution.

Rod Soaking Device.—In another construction of soaking device the bottles are attached to rods and moved by the two endless chains supporting these rods through a soaking solution. Coming out at the other end the bottles are removed, the speed of the chain being such that the bottles are submerged for the desired soaking period. No bottles need be carried back through the air, thereby saving time. There are two compartments—a large one for soaking and a smaller one for draining and removing labels.

SOAKING DEVICE ACCESSORIES.

For the purpose of removing the old tin foil from bottles, as well as for extracting any corks contained in them, there should be attached to every soaking device an apparatus for that purpose. It should be conveniently placed for use before the bottles are soaked, and not afterward, as is quite often the practice.

Tin-foil Removers.—As most of the bottles that were capped with tin foil are returned to the bottle shop with the greater part of their foil still adhering to them, it is advisable to remove the same before recapping, as otherwise the capping with new foil may not adhere properly, or, if so, the repeated layers may present an unfinished or rough appearance. As soaking has practically no effect on this old tin-foil, because the soaking solution cannot penetrate through the metal to moisten the paste

underneath, it must be removed or scraped off by some mechanical means.

The appliance most generally used for this purpose consists of a rotary shaft, around which are attached eight flexible arms each holding at its outer end a serrated wheel with cutter teeth On inserting a bottle between these wheels their teeth cut or scrape a furrow through the tin foil, and, by moving the bottle inward and outward, it requires but an instant to remove the foil completely. The purpose of the teeth in these wheels is to remove the foil in chips or in fine spiral ribbons so that they will be dropped or whirled out, as, if the foil were scraped off in the form of a sheet, it would ball together and soon clog the machine. Surrounding these wheels is attached a basket of wire gauze for the purpose of preventing any chips from being thrown about or in the face of the operator, and to furnish a means for collecting the waste, which is quite a profitable recovery, as it is salable, at 8 to 10 cents per pound, and about 60 per cent of the amount of foil originally used is recovered by the use of this apparatus.

Cork Extractors.—As quite a few bottles are returned containing a cork or a piece of it, which must be removed before again filling the bottles and preferably before soaking, as their presence is an annoyance during that part of the process, a rapid-action cork extractor becomes an appliance of considerable economy. One which has found its way into general favor consists of a tube containing several spring wire claw-hooks which, by one motion of a handle, are raised into the inverted bottle placed over them, where they spread, surround and grasp the cork, and, by another motion of the handle, are lowered thereby extracting the cork, irrespective of its shape or size.

WASHING AND RINSING.

The next manipulation after soaking that is necessary in order to prepare the bottles for filling with the brewers' product is that of washing and rinsing.

Although this part of the process is often hurried, it being considered by some bottlers necessary only to rinse the adhering soaking solution from the bottles, it nevertheless is very important, as in some instances the washing machine must also perform the work of the soaking tank. It happens frequently that bottles contain substances that are not completely

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or are entirely unaffected in the soaking solution. It then becomes the duty of the bottle-washing machine to remove these substances by friction.

The modern designs of bottle-washing machines are divided into two classes, viz. those employing revolving brushes and those using shot as a means of applying frictional cleansing action to the interior surfaces of the bottle.

Brush Machines are those in which the washing is performed by the revolving and consequent centrifugal spreading of brushes of different shapes, or of the sections of a split rubber tube, or rod, or other shape differing with each style of machine. Brush machines have the advantage of rapid manipulation, and are of special service in washing bottles containing only a small amount of foreign matter to be removed, or such as contain it in a soft or jelly-like condition.

Shotting Machines are those employing shot or sharp-edged small pieces of other metals or porcelain for the purpose of applying the friction in the bottle. In these machines the bottles are usually shaken or jerked in a forward and backward motion so that the shot is hurled forward and backward in a line similar to a figure oo. The bottle is also partly revolved after each stroke of the machine to make the shot strike a new portion of the interior surface of the bottle at the next stroke. Shot machines have been found to be especially effective where the foreign matter to be removed consists of a hard or tightly-adhering coating in the bottle, which would be removed with difficulty, if at all, by a brush machine.

Shot machines, however, have a disadvantage in the fact that the necks of the bottles are not subjected to the same vigorous cleansing action of the shot as received by the body of the bottle. This is due to the fact that the shot, when hurled toward the neck of the bottle, usually strikes the shoulder and rebounds, falling into the neck with greatly diminished force. This diminished efficiency is also to some degree the drawback in brush machines employing rubber brushes where the full frictional action is not obtained until the rubbers have spread, which they do only partially while in the neck of the bottle. In using bristle brushes, however, with these machines the neck receives the same, or even a more thorough, scouring than the remainder of the bottle, as the bristles are compressed while passing through the *neck, and*, as the bristles depend upon their own elastic

as much as upon centrifugal force for spreading, this compression while in the neck of the bottle only tends to add to their efficiency.

A bottle-washing machine should be judged, however, principally by its efficiency in cleansing the body and bottom of the bottle, as it is here, especially on the latter, that the most stubborn crust of foreign matter is usually found, the necks being in most instances quite easily cleaned.

Rinsing Machines are devices for the purpose of finally removing, by means of a spray or jet of clean water, such loosened matter as may still adhere to the inner surface of the bottles after the water used in washing has been emptied out. They are either separate devices, upon which the bottles are placed for rinsing after they are removed from the washing machine, or else are attached to, and operated with, the washing machine automatically.

SINGLE BOTTLE WASHING MACHINES.

The ordinary style of single bottle washing machine is today the most universally used machine, being installed in the majority of bottle shops, even in those using the more modern multiple washers, finding ready use on account of its rapid and convenient manipulation.

This machine consists of a hollow revolving shaft or spindle, to one end of which is attached a brush made of different substances, such as bristles, rubber, etc. This brush is surrounded by a ferrule or housing which keeps it from spreading by centrifugal force while revolving, and also has the purpose of keeping the brush compressed, so that it will readily enter the mouth of the bottle. This housing is movable forward and backward in the line of the spindle, and is supplied with a flanged or bell-shaped lip, so that when the mouth of a bottle is pressed into the same, the housing recedes and the neck of the bottle occupies its former position. Upon further moving the bottle forward, so that its body surrounds the brush, the latter is released from any compression and immediately spreads and rubs or scrapes the inside of every part of the bottle. At the time when the brush leaves the neck and enters the bottle, a stream of water is automatically turned on by means of an arm or rod connecting with a cock in the water supply. This water passes through the hollow revolving shaft, entering the bottle in the form of a jet or spray, and, by the opposite motion in removing

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the bottle, the water is shut off so that none escapes except while the bottle is being washed.

These machines are constructed to supply almost any demand that bottle shops of different capacities may make. They are built to operate either by foot, steam or water power, and made with one, two or four spindles to each machine, in the latter kind all being driven from one countershaft.

Another style of this machine has lately come into use. This consists of two horizontal brush spindles, operating as above described, the economical feature being in the machine having two bottle holders or carriages moveable forward and backward by a screw revolved by power. One man can, therefore, do double the work he could do on a single machine. He need not press the bottles against the brushes, as the revolving screw accomplishes this motion, the operator's work being only to remove washed, and replace by unwashed, bottles.

MULTIPLE BOTTLE-WASHING MACHINES.

Multiple Brush Machine.—A popular style washes 16 bottles at once. The operation is as follows: The 16 bottles are placed in a rack constructed to hold them at regular distances apart, which, upon being placed on the machine, allows the mouth or lip of each bottle to rest in a corresponding cup-shaped depression. A lever is now depressed, which acts upon a plate and presses or tightens the bottles, so that they are firmly held in position while washed. By lowering another lever at the side of the machine, 16 revolving spindles and brushes are raised upward and into the bottles, and, by their centrifugal spreading, the bottles are scrubbed in the same manner as described in the operation of the single brush horizontal washers. In fact, the operation of this machine is in principle very similar to that of the single-brush machines, the main difference being in its construction.

The advantages of this multiple machine over the horizontal single-spindle machine are the following: The bottles are not held in the hands of the workman while the spindles are revolving, hence, any bottle that may be broken during washing is not likely to cause any cuts or other injury. Furthermore, as the bottles are in a vertical position, the dirty rinsing water is continuously running out, and the brushes, as they move upward or downward, are always being supplied with new and

clean water, which, in bottles containing sediments of a gelatinous or soapy nature, greatly facilitates cleaning.

Multiple Shot Machines.—Another style of multiple machine, using shot, washes 12 bottles, 6 in a reel, at one operation. The machine consists of a shaft carrying at each end 6 pockets for bottles, to which is given a rotary and longitudinal motion, hurling the shot against all parts of the inner surfaces of the bottles.

Another type of multiple machine using shot is similar in its operation, but of much larger construction and capacity and washes 18 bottles at one time. The length of time the bottles are scoured is regulated by the foreman changing a set-screw, and is not left to the boy operating the machine. Once set, the machine will continue to make the same number of vibrations and revolutions till set again by the foreman. When scoured, the bottles are automatically inverted and rinsed with a jet of clean water to remove any particles of sediment and impurity adhering to the bottles. The bottle crate holds 18 bottles, and after rinsing, the crate of cleaned bottles is replaced by a crate of dirty ones in a few seconds. The capacity of this washer is from 150 to 180 dozen bottles per hour. It will wash quarts, pints or half pints, and bottles with any and every kind of patent stoppers.

The shot or slugs used in shotting machines are generally made of steel, and in shape resemble a double pyramid with bases together. The sides of the shot are also curved inward, so as to present as many points or sharp edges to the glass as possible, thus increasing the abrasive or scouring action of the shot and also lessening their tendency to stick to the wet interior surfaces of the bottles, or choke the mouth in falling out.

Small steel punchings, about 1-16 inch in diameter, are also used and give satisfactory results.

ADVANTAGES OF THE DIFFERENT WASHING MACHINES.

Comparing the different styles of washing machines with each other, it is seen that different types have advantages peculiarly their own, which may be summed up as follows:

Brush machines are practically noiseless in their operation. The time of washing the bottles can be lengthened or shortened to suit the conditions of the bottles, and they require comparatively little power, as the spindles only are revolved and not the heavier bottles. They, however, require freque

newal of the brushes if the machines are to work to the best advantage.

Shotting machines are more vigorous in their cleansing action upon hard resistant crusts, the shot is cheap and remains in good condition for a long time. Shot machines, on account of their unbalanced motion, require a good foundation and make considerable noise. This very noise, however, according to some bottle-shop foremen, gives a control of the whole line of work, as the bottles are placed in the machine in crates or racks, and the machine once started operates automatically until the necessary turns are made, and then stops, when it is the attendant's duty to remove the crate, put in another and at once start the machine. Should the machine remain silent too long, which can be heard from any part of the bottle shop, the foreman knows that somebody is not keeping up with his work, and investigates the cause.

BOTTLE-RINSING DEVICES.

After a bottle has been scrubbed on the washing machine it generally contains, adhering to its inner walls, some of the wash water in a more or less dirty condition. This water must be removed before the bottle can be filled with beer, and to accomplish this end the bottle is rinsed, or, in other words, this dirty water is displaced by clean water, entering in the form of a jet or spray so arranged as quickly to come in contact with every part of the inner surface of the bottle.

In washing machines, on which bottles are held in an inverted position with their mouths downward, the washing spray of water also acts as a rinsing spray at the moment when the brushes cease revolving, or the shot has fallen out of the bottle, but in machines where the bottles are held in a horizontal position while being washed, this combination feature cannot be applied. Here the bottles must be taken from the washing machine and placed on a rinsing device, which involves another separate manipulation.

The general form of rinser, now in use, consists of a series of upright tubes, each having a hole or nozzle at its upper end for the emission of the water spray. Around each of these tubes is attached a bottle support, consisting of a claw or ring, made to fit around the mouth of the bottles and placed at such a distance below the upper ends of the tubes that the latter will extend about halfway into the inverted bottles place

over them. All of these tubes, whatever their number, are inserted at their lower ends into a connecting header, and this header is placed over, and attached to a plug of a stop cock or valve in such a manner that, after the rinsing device is filled with bottles, it is given a quarter turn, whereby the water supply is turned on, allowing the water to pass through the tubes and perform its rinsing duty. In order to prevent chipping of the mouth of the bottle, the supporting claws or rings are often made of or lined with rubber, because it happens that the bottles are often quite carelessly placed upon the rinser.

COMBINED SOAKING, WASHING AND RINSING DEVICES.

Very convenient forms of combined outfit for bottle soaking, washing and rinsing are now on the market, and are well adapted for use in bottle shops where compactness is a desired feature. These outfits consist of a wooden soaking tank of convenient size, to the sides of which are attached a horizontal single washing machine, a rinsing device, also a tin-foil remover and cork extractor, all of these being conveniently arranged, and the whole forming a very compact outfit so that one man can handle the bottles without much loss of time in moving about.

TAPPING OF BARRELS.

In tapping barrels care must be taken not to lose any beer or gas, and for this purpose a special device is used. This consists of a tube reaching to the bottom of the barrel and having side openings at its lower end for the passage of the beer. This tube passes through a bushing, having a side opening with check valve, for passage of the air pressure to the surface of the beer necessary to force the beer through the tube and into the filler. In practice several barrels are thus tapped at one time, and their delivery pipes connected whereby a more even and long flow to the filler is obtained, and at the same time less time is lost by the filling operator waiting for a new supply.

One style of these tapping devices employs a special bush that must be screwed into the barrel permanently. This has the advantage that such a barrel will always be at the disposal of the bottling department, and not used for customers or shipment.

When feeding back pressure bottle filling machines a drawback and annoyance is often experienced when tapping and running a new barrel to the filler. This happens when the air or

gas contained in the connecting tube or hose is forced through the filling machine, causing the latter to "sputter." In order to overcome this defect there is now a device on the market so constructed that a new barrel can be attached without the operator taking notice of the change, and this is accomplished by an arrangement whereby several barrels are cross-connected to a main header, or manifold, so that one barrel can be disconnected and another replaced without the flow of beer being interrupted.

The essential feature of the device consists of a "lantern" or observation glass placed between the barrel and the header. At the lower end of the lantern the supply and discharge pipes are attached, while the upper is supplied with a blow-off cock and the opening closed or opened by means of a float or rubber ball.

The operation is as follows: When the beer is discharging the lantern is full so that the ball floats at the top and closes the air cock. As the flow diminishes the lantern empties and at the same time the float descends to a point below the opening to the header, whereupon the cock to same is closed so as to prevent back pressure when the barrel is disconnected. The empty barrel is now replaced by a full one (the other barrels supplying the flow during the operation) and as long as the air or gas from the barrel or tube passes into the lantern, so long it passes over the float and out of the air vent. As soon as beer is discharged into the lantern the float rises until it is pressed against the air cock, when the cock to the header is opened and the beer flows to the filling machine, and by placing the barrels so that they empty alternately a continuous flow is obtained.

BOTTLE FILLING.

The bottles having now been properly prepared, the next operation necessary in the bottling process is the filling of the bottles with beer.

The two principal precautions to be here observed are, first, to guard against the escape of the carbonic acid gas contained in the beer, and, second, to prevent an infection of the beer by foreign micro-organisms, while it is being transferred from barrel to bottle.

TROUGH SIPHON FILLER.

The form of bottle-filling device now in most common use is the trough siphon filler. This consists of an oblong trough-shaped receptacle, with a cover fitting more or less tight an

supplied internally with a float indicator so that the surface of the beer, when in this filler, can readily be kept at the desired level. Through one of the long sides of this filler are inserted a number of siphon tubes, each bent in a shape similar to a letter J. The curved part of this tube is placed inside of the trough and the straight part outside of same, the tube being attached to the walls of the trough and pivoted at the point where it passes through, in such a manner that its ends can be raised and lowered a few inches. The tube is open at its curved inside end except when this end is depressed, in which case the opening is closed by being forced against a rubber disc or washer. The outer straight part of the tube is tapered at its end and closed, a small slot or opening, however, being cut a short distance above this end.

The operation of this siphon tube is as follows: By placing a bottle over its outer straight end and depressing it, the slotted opening is lowered and at the same time the inner curved end is raised away from the rubber closing disc, which allows the beer to flow or siphon into the bottle, the flow continuing until the surface level of the beer in the bottle has reached the same height as the surface level of the beer in the trough. After removing the filled bottle the tube is again closed automatically by means of either a spring or a weight forcing down the inside opening of the tube against the rubber closure. In regulating the height of the level of the beer in the fillers allowance should be made for the quantity of beer displaced by the tube while in the bottle. This can be done by filling the bottle to the brim, when, upon removing the tube, its displacement will usually equal the unfilled space desired in the bottle. This air space is of great importance, as it furnishes a cushion for the expansive force of the beer when subjected to a higher temperature than that prevailing at the time of bottling. In the event the bottle were completly filled with beer, any such expansion would tend to expel the stopper or burst the bottle, and would certainly do so during the subsequent steaming process wherein the temperature and pressure of the beer in the bottle become quite high.

As the beer before it reaches the bottles is usually, during this transfer, brought more or less in contact with air, which means a possible chance of infection by foreign micro-organisms,

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all modern fillers are constructed in a manner tending to reduce this contact to a minimum.

Porcelain-lined or Enameled Trough Filler with Air Filter.—A neat and practical system for bottle filling employs purified air. This system consists of a trough bottle filler, which possesses the novel feature of having its inside, with which the beer comes in contact, porcelain lined or enameled (making an easily cleaned filler), preventing the beer from coming in contact with metal surfaces. To this filler is attached an air filter for the purpose of removing any foreign substances from the air while the latter passes from the air reservoir, also a part of this system, to the supply barrels.

BACK OR COUNTER PRESSURE BOTTLE FILLERS.

The different styles of trough bottle fillers now on the market possess, as a class, a drawback in the feature that they allow more or less carbonic acid gas to escape from the beer during the filling operation. Since the quantity of carbonic acid gas that a liquid will contain or hold in solution depends partly upon the amount of pressure resting upon its surface, it follows that, when this pressure is reduced, a corresponding escape of gas from the liquid takes place.

In order to overcome this loss of gas or reduce it to a minimum some styles of bottle fillers are constructed so as to operate in such a manner that the beer, during the time it is being filled into the bottle, is continuously subjected to a pressure sufficiently great to prevent the escape of any of its contained carbonic acid gas. The principle, however, by which the beer flows into the bottle, or by which this flow is started or interrupted, is that of the siphon above described, and not the employment of the force of any extra pressure, as this pressure is practically the same upon both the beer in the filler, in the reservoir and in the bottle, and any excess pressure, due to the displacement of the air in the bottle, is blown off automatically from the back pressure chamber.

A disadvantage, however, of this form of back pressure bottle filler lies in the fact that the contents of bottles that may be chipped, cracked or partly broken during any of the different stages of the bottling process, and which contents may amount to a considerable quantity during the course of the day, cannot be returned or poured back into a filling device, as can be done *with the open trough style* of bottle filler.

The most universally used of this kind of bottle fillers operating upon the back-pressure system consists of a stand supporting two air-tight brass tubes or cylinders. The lower and larger one of these is used as the beer reservoir, corresponding to the trough of the trough filler, and has attached to it the siphons, bottle-holding clamps and shut-off valves or cocks. The upper or back-pressure reservoir is connected with the bottles to be filled and is used as a receptacle for containing the pressure producing air or gas; it is supplied with a diaphragm by-pass or blow-off regulating valve for the purpose of automatically regulating the back pressure and blowing off the displaced air from the bottles after they are filled. The siphons operate similarly to those of the ordinary trough filler described; the bottle-holding claws and the beer and pressure shut-off valves are so constructed that, when the siphon tubes are raised, the claws open and release the bottles, and, at the same time, the shut-off valves close and simultaneously interrupt both the flow of the beer and the back pressure, so that the bottles can be removed without loss of either.

This filler is also made of a round revolving pattern, offering the advantage of compactness and requiring less moving about on the part of the operator.

Another style of rotary back-pressure filler is fed from below and has a glass lantern, containing a float ball, to regulate the flow and back pressure.

BOTTLE CLOSING OR STOPPERING.

After the bottle has been filled with beer, the next operation necessary is to close the bottle as quickly as possible. This has in view a double purpose—namely, to prevent any escape of carbonic acid gas and to avoid subjecting the beer to the chances of an infection by germs floating in the air.

CORKS.

The oldest form of bottle closure is the cork, which still maintains its standing at the present time, and which is too well known to require description. The cork, however, has the following disadvantages: That it is often difficult to extract the cork from the bottle, causing, by the attempt to do so, the beer to be agitated and to foam excessively when poured out; that pieces of cork often fall into the beer if a dull corkscrew is used; that, in compressing the moist cork, which happens just previous to its insertion, a juice or liquor is squeezed out which usually

drops into the beer and may afterward affect its appearance; and, lastly, that if a poor quality of cork has been used the bottle may not be hermetically closed thereby, allowing the escape of the carbonic acid gas, and, in extreme cases, even spillage of the beer.

In order to overcome these defects, and for the purpose of cheapening the cost of bottle closures, various devices have been put upon the market, of which the following are the principal ones in use:

PERMANENTLY ATTACHED STOPPERS.

Patent Stoppers.—The form of closure most commonly used on bottles containing beer of which a high degree of durability is not required and which is supposed to be consumed soon after leaving the brewery, is the "patent stopper." It consists of a rubber button or plug, through which passes a wire loop, inserted at its ends into a movable wire lever or clamp, fastened permanently around the neck of the bottle. By depressing this clamp the wire loop is lowered and at the same time the rubber plug clamped tightly over the mouth of the bottle.

The advantages of the patent stopper over all other closures lie in the facts that the bottles supplied with it can be opened by hand, require no corkscrew or other tool, and that they necessitate no renewal of the closure each time the bottle is refilled, thus effecting a considerable saving in the cost of closures.

The disadvantages, on the other hand, possessed by the patent stopper, are that the disc of rubber which covers the opening of the bottle comes in contact with the beer, and is not very easily thoroughly washed and sterilized. This washing, etc., is rendered more difficult by the crevices in the rubber disc; furthermore, bottles having patent stoppers offer a temptation to the customers to keep them for use for other purposes, as the closure is always at hand, ready for use and easily applied.

Porcelain Stopper.—In order to overcome some of the disadvantages possessed by the ordinary patent stopper having the rubber seal, other styles employ a conical porcelain plug, to which is attached as a seal a smooth rubber washer, easily replaced when it shows any wear, and affording a perfectly tight closure on account of its tapering position on the plug.

SINGLE-USE STOPPERS.

All other forms of stoppers in use are of the "single-use" kind; *that is, the stoppers* are not permanently attached to the bottle

but are thrown away and not re-used after the bottle has been opened. This style of stopper does away with the possibility of any impurities from any former contents of the bottle finding their way into the bottle, since at each filling a new stopper is inserted. These stoppers possess the advantage of more universally supplying a tight closure, which is not the case with some of the old style patent stoppers in which the rubber becomes worn or hardened. These stoppers, although more expensive, further allow the bottle being capped or wrapped with tin foil, etc., affording an opportunity for preparing a neater appearing package.

Metal Plug Stoppers.—One style of these single-use stoppers consists of a hollow cup-shaped plug, made of aluminum. After insertion into the mouth of the bottle the sides of the stopper are expanded into a special groove or recess in the inside of the mouth of the bottle, a rubber ring or gasket having been previously placed around the stopper, so as to form an additional air-tight seal between metal and glass.

Flanged Disc Stoppers.—Another style of single-use closure consists of a flat tin-plate disc, having a flanged and crimped edge and containing a thin disc of cork on its inside for the purpose of supplying the closing seal when affixed to the bottle. The cork disc employed is specially treated for the elimination of impurities and is then saturated with a neutral and inert water-proofing compound. Between this cork and the metal disc proper a sheet of prepared paper is inserted to prevent its contact with the tin. The flange and corrugations on the metal are compressed by a machine which secures them around the bottle head and under a shoulder formed thereon, thus insuring the proper compressions to the cork disc to make a gas-tight joint and holding the metal disc firmly in place. With this closure there is no possibility of injecting objectionable residual liquids into the contents of the bottles from the cork in the act of crowning, or of such dissolving out thereafter, as is well known to be the case in the compression of ordinary corks, old or new. That part of the cork disc which is placed under compression never comes in contact with the contents of the bottle; and the body of the cork which is in contact is extremely thin as compared with the length of the ordinary cork.

Another style of closure consists of a cup-shaped tin capsule,

similar to the lid of a round pill box, containing a disc or washer of cork. This capsule is secured to the neck of the bottle by a circular strip of tin, the top edge of which is bent at right angles, so as to form a flange over the capsule.

In affixing the same the capsule and circular strip are compressed over the bottle, and while in this compressed state four wheels gather together and revolve and turn inward or "spin" the other edge of the circular strip under the shoulder or offset of the lip of the bottle.

The main feature of this closure is, however, that the closure can be removed from the bottle by hand, requiring no tool. This is accomplished by having one end of the circular strip pass through a slot in the other and protrude or extend therefrom. To open the bottle this tin protrusion is bent back, by which the circular ring is opened and the closing capsule loosened and removed, a movement similar to loosening a strap from a buckle.

Another style of similar closure consists of a cup-shaped capsule containing a disc of cork, like the above described closure, but having its sides or cylindrical part much longer. These sides have three indentations which fit into spiral recesses in the lip of the bottle. In affixing the closure the capsule is compressed over the bottle and then given a turn by which the closure is simply screwed on by about a turn of one-sixth revolution. By the reverse turn by hand the closure can be readily removed from the bottle.

Rubber Disc Stoppers.—Another closure consists of a disc of rubber, about one-third of an inch in thickness, coated upon the side coming in contact with the contents of the bottle with a specially prepared textile fabric, saturated and covered with an inert, tasteless and odorless compound, to prevent contact of the rubber with the liquids. This rubber seal is elastically forced by machines into a specially prepared groove formed in the mouth of the bottle. It contains a wire loop, projecting from the top surface, by means of which it is readily extracted by suitable openers or by any stout-pointed instrument. When about to be inserted in the bottle the rubber disc is tapered up by the machine so as to enter the neck readily, expanding after insertion so as to fill the full width of the neck. In steaming it will expand or contract with the bottle.

Economical advantages gained by the use of these types c

single-use closures lie in the facts that the extra operation of wiring, and that of the two operations of affixing and removing the steaming caps before and after pasteurization is entirely done away with since these closures have been found to remain immovable at the pressures generated in the bottles during the steaming process. Another and considerable advantage possessed by these closures is that they can be removed from the bottles with ease by use of special accompanying openers, or, in fact, with any pointed instrument, or by hand, and thus prevent agitation of the beverage while the bottle is being opened.

BOTTLE-CLOSING MACHINES.

The machines employed for inserting or affixing the different closures described are, with the exception of corking machines, manufactured especially for use with each style of closure.

Corking Machines differ little from each other in the principle of operation, which is as follows: The corks are thrown into a funnel, and drop one by one into a cylindrical clamp, where, by means of a horizontally-acting plunger, having a circular-shaped recess, the cork is compressed to a size somewhat smaller than the opening in the bottle. While in this state a vertically descending round plunger forces the compressed cork into the bottle, where it expands and conforms in shape to that of the inside of the bottle, thereby effecting an air-tight seal.

CORK-CLEANING, SOFTENING AND WASHING MACHINES.

Cork-cleaning, softening and washing machines consist of a revolving horizontal drum, having its cylinder constructed from slats or strips of wood, arranged with spaces between them. The corks are placed in this cage-like cylinder, which is then revolved, whereby the fine, powder-like substances contained in the outside veins of the cork, and which might otherwise find their way into the bottle, are removed or shaken out by the concussion of the corks against each other. Other forms have this cylinder placed over a tank so as to partly revolve under water for the purpose of soaking or cleaning the corks, or else have a central water pipe with perforations lengthwise as a means of sprinkling the corks for soaking and washing purposes.

TREATMENT OF CORKS.

A cork, when properly treated, should be elastic and when in the compressed state previously to insertion into the bottle, should

not give off any pressed out liquid, since this liquid is likely to drop into, or come in contact with, the beer, and affect its brilliancy.

The corks are first rumbled dry in a revolving drum for several hours in order to remove the brown cork dust in their veins. They are then further rumbled with a spray of water for about 30 minutes or, where the apparatus has no central perforated shaft for water to spray, the corks can be placed in a vessel and the water changed continuously for about 30 minutes. The corks are then put into water of 178° F. (65° R.). Higher temperatures, especially boiling water, may injure the corks. Bisulphite of lime is added to a distinct odor (about one pint to 6 gallons of water) and the corks allowed to remain until soft, which usually requires from 15 to 30 minutes. The corks are then transferred to a wire basket and immersed in a glycerin solution of 156° F. (55° R.) and kept here for about 30 minutes. This glycerin solution is made by adding one volume of glycerin to about three to five volumes of water, according to the quality of the corks used or softness desired.

The corks are finally allowed to drain, and then stored in a clean perforated barrel, that is, one having holes bored through the sides, bottom and cover. By this treatment the corks will be ready for use in about 24 hours and will remain in condition for immediate use for three to four days.

CORK PREPARING APPARATUS.

As it is a difficult and slow operation to impregnate wet or soaked corks, that is, such as have their pores full of water, with a different kind of liquid or solution by contact, a special apparatus for rapidly and thoroughly accomplishing this process has lately come into use.

The principle here employed is that the dry corks are placed in a vacuum, whereby most of the air contained in the pores is extracted and subsequently replaced by the impregnating fluid with which the corks are allowed to come in contact.

The operation of this apparatus is as follows: The corks, after being rumbled to remove any loose powder contained in their pores, are placed in a drum-shaped receptacle into which live steam is then allowed to enter until all the contained air is displaced. The drum is then hermetically closed, and cold water *sprayed over its outside*, whereby the steam inside the drum is

condensed and a vacuum formed. Through a valve the proper amount of impregnating fluid is then admitted, and the drum revolved so that the corks will be thoroughly moistened or covered with the liquid. Another valve is then opened so as to let air into the drum and relieve the vacuum, whereby the liquid is forced into the pores of the corks by the atmospheric pressure on their surface.

CORK-BRANDING MACHINES.

Cork-branding machines are rapidly coming into more general use among bottlers since the branding of corks with the name of the brewer and date of bottling possesses desirable features in both furnishing an advertisement for the brewer and giving a control as to the date of bottling. The branding machines now in use empioy either gas, gasoline or electricity as a heating agent, and are so constructed that the corks, placed in a hopper, drop through a tube and are forced between revolving pulleys or rollers, which pass or revolve the cork over or across a heated metallic die similar to a small branding iron. The operation is very rapid and sufficient corks can be branded for daily use in a comparatively short time.

WIRING.

In order to prevent the corks from being expelled from the bottle by internal pressure, caused by the carbonic acid gas, or by the extra pressure generated during steaming, bottles closed with corks are generally wired; that is, a wire loop is placed around the ring flange of the neck of the bottle and the ends bent upward and spirally twisted together over the opening of the bottle, thus keeping the cork in position. In order better to keep this wire clamp in an immovable position, and to give the package a neater appearance, variously shaped corrugated stamped discs of tin are placed between the wire and the cork.

Bottle-Wiring Machines.—Wiring bottles, when done by hand, is a laborious operation, and a machine has been designed and constructed to accomplish this manipulation in an even, neat and rapid manner. This machine operates automatically, it being necessary only to press the bottle against the wire loop held by the jaws of the machine, when, by depressing the foot lever, the bottle is wired, the wire trimmed, and another loop made and held in position ready to be put on the next bottle. The capacity of this machine, when properly operated, is about 1,000 bottles

per hour, which is approximately four times the number usually finished when done by hand.

BOTTLE CAPS.

A style of bottle cap much used and easily affixed and removed from the bottle consists of a flat tin disc, to which three strips are attached and bent downward at right-angles. The strips are again attached at their lower ends to a circularly-bent tin band or strip having a slot cut at one end, and the other end tapered so as to fit into this slot. In affixing the cap, the tapered end is inserted through the slot and its protruding part bent backward, whereby the circular strip is tightened or clamped around the flange on the neck of the bottle, for the purpose of holding the disc firmly over the cork.

CORKING, CAPPING AND WIRING MACHINES.

In order to bring the cost of corking, capping and wiring to a minimum, an automatic machine, combining these three operations, has been designed and placed on the market. In the operation of this machine the bottles are placed into a revolving attachment holding six bottles, in which they are successively corked, capped with a disc and wired automatically at the rate of about twenty bottles a minute by but one operator. This machine adjusts itself to take any size bottles, and the corks need not be handled, as they discharge automatically from a hopper to where wanted. The machine has another advantage in the fact that the cork is compressed before the bottles come under the compressor, preventing the troublesome cork juice from dropping into the beer.

BOTTLE BOXES.

These are so well known in general appearance as to require no detailed description. Attention should, however, be called to the construction of the cross-partitions separating the bottles, which should either be raised from the bottom of the box or tapered downward. This causes the bottles, when the case is placed on end, as is a common custom of the consumer for the purpose of economizing space, to assume a slanting position, with bottoms lower than the necks, and thus prevent them from falling out.

PASTEURIZATION, OR "STEAMING."

The process in the bottling department known as pasteurization is the manipulation of heating the beer in the bottles to a

certain temperature, holding this temperature constant for a certain length of time, and, finally, cooling to nearly ordinary atmospheric temperature. The object of this heating of the beer is to kill any yeast cells or other micro-organisms that may be contained in it, or to weaken their vitality to such an extent as to render them inactive, and thereby prevent any further fermentation or decomposition of the bottled beer which might otherwise have taken place.

In order to carry out this pasteurization manipulation, the bottles containing the beer are placed in a tank, which is then filled with cold water. This water is gradually heated to the desired temperature by means of injected live steam (hence the more popular term "steaming") ana the warm water afterward gradually cooled by being mixed with an incoming stream or jet of cold water. By this means the beer is gradually heated by taking up heat from the surrounding water, and, later on, giving off this heat to the cold water.

IMPORTANCE OF PASTEURIZATION.

There is no part of the bottling manipulation of more importance, nor one which, if improperly executed, can give rise to more serious annoyances and loss of money or reputation for excellence of the bottled product, than this process of "steaming" or pasteurizing. During all of the many stages or processes through which the beer passes while being manufactured, any abnormal change in its quality or appearance can be readily detected by a competent and careful brewer, and the proper remedies applied before the product has left the brewery. An exception to this, however, is the pasteurization of the bottled beer, since this part of the process takes place just previous to shipping or placing the beer in the market, and it is, therefore, practically impossible to test it in the time at disposal. Hence, any deterioration of the beer, due to improper or incomplete pasteurization, usually manifests itself while the product is in the hands of the consumer. The results, in this event, are, almost universally, that the brewer is blamed for having produced an inferior beer, even though, in reality, the beer may have been of excellent quality and the greatest care and skill possible been exercised *during* every stage of its production in the brewery.

At the present time, instances where all the beer contained in *the "steaming"* tank has proved to have been improperly heated

are not of such frequent occurrence as was formerly the case. There is one trouble, however, that quite frequently presents itself, and has puzzled many brewers. This is where the beer from the same chip cask has been filled into bottles and "steamed" in the same tank at the same time, with the result that a few of the bottles of beer proved to have been improperly "steamed," while the others had been properly treated. The cause of this trouble has usually been found either in the defective construction of the tank or heating apparatus, causing the lower tiers of bottles or those in the corners of the tank to be insufficiently heated on account of defective circulation of the water, or else in an improper arrangement of the bottles themselves, being placed either too close together when the tank was filled with single bottles, or being put in wooden boxes made of solid boards and allowing practically no circulation of the water through them.

PRECAUTIONS IN PASTEURIZING.

In order properly to carry out the steaming or pasteurizing process in the most economical manner, the following precautions should be observed:

1. The raising and lowering of the temperature of the water surrounding the bottles should be done gradually in order to reduce the liability of breakage of bottles.

2. The length of time for holding beer at the desired pasteurization temperature should be such that all the contents of the bottle are subjected to the same maximum temperature. As the beer in the bottle remains at rest during steaming, there is practically no circulation or mixing of the warmer beer from the outside with the colder inside portion. Furthermore, as the bottom of the bottle is usually of thicker glass than the walls, and rests upon the wooden grate or support, thereby coming only partly in contact with the warmer water, it is evident that up and down circulation is prevented and it takes considerably longer for this central portion to warm to the desired degree of heat.

3. The beer in the bottle should not be heated for a longer time or to a higher degree of heat than is necessary to pasteurize it, on account of the liability of the product to acquire the objectionable so-called "steam" or "bread taste." Furthermore, such heating is apt to coagulate and precipitate some of the albumen contained in the beer, causing haziness or turbidity or con-

sequent sediment. Excessive heating also involves the danger of forcing out corks or stoppers, or of exploding the bottles, since the pressure of the carbonic acid gas, in such event, becomes very great, and some bottles will break which would otherwise have withstood the pressure at the normal temperature.

ERRORS TO BE AVOIDED.

The success to be obtained in the process of pasteurization of bottle beer depends not only upon a proper construction of the "steaming" tank, but also, to a very large extent, upon the manner in which the water is heated.

A very common hindrance to a proper steaming process lies in the use of improperly constructed wooden steaming trays or boxes for holding the bottles while in the tank. In order to have such boxes strong and durable, they are often constructed of heavy lumber, with practically no spaces or holes in their sides, ends and bottom to allow the circulation of the heating water through them.

Where these boxes are not employed, it is customary to place the bottles in the tank singly, which is a preferable but more time-consuming method. Here, also, an error in manipulation is frequently met with, in the fact that the bottles are placed too close together, because it is much easier for the workman to place the bottles touching each other than to place them apart in every direction, which requires care and mental effort on his part.

A further cause of improper pasteurization of the beer, besides the mechanical defects mentioned, is an insufficient length of time of holding the maximum temperature in the water, so that the beer in the centers of the bottles does not reach this maximum temperature at all, or for too short a time.

In order to determine the time when the beer in the center of the bottle reaches the maximum temperature, a series of tests were carried out, the averages of the results being given in the table on next page.

In these tests, made with "export" size bottles, the beer was heated from 41° F. (4° R.) and the water from 68° F. (16° R.) these representing average temperatures. The water was in every test raised to 140° F. (48° R.) in 30 minutes.

From these results it will be seen that pints require 20 minutes and quarts 35 minutes longer heating before all their contents

reach 48° R. than does the water, while, when the cooling begins, the decrease in temperature is quite rapid. It is also seen that the opinion of some bottlers, that the beer will hold the highest temperature for as long a time after cooling begins as it took to gain it after the water had reached it, is incorrect. For instance, at ten minutes before the time quarts reach 48° R., their temperature is 47.5° R., while that of the water is 48° R., a difference of half a degree, whereas during the first ten minutes of cooling there is a difference in temperature between the beer and the water of 8° R.

TEMPERATURES DURING PASTEURIZATION.

Time.	Temperature of Water.		Temperature of Beer in Center of Bottle.			
			Pints.		Quarts.	
Start heating	68.° F.	16.° R.	41.° F.	4.° R.	41.° F.	4.° R.
15 minutes	104.° F.	32.° R.	87.8° F.	24.8° R.	82.4° F.	22.4° R.
30 minutes	**140.°** F.	**48.°** R.	125.6° F.	41.6° R.	121.6° F.	39.6° R.
35 minutes	....		133.7° F.	45.2° R.	129.2° F.	43.2° R.
40 minutes	....		138.2° F.	47.2° R.	134.7° F.	45.6° R.
45 minutes	....		139.6° F.	47.8° R.	136.4° F.	46.4° R.
50 minutes	....		**140.°** F.	**48.°** R.	137.85° F.	47.° R.
55 minutes	....		....		138.68° F.	47.5° R.
60 minutes	....		....		139.65° F.	47.8° R.
1 hour 5 minutes	....		....		**140.°** F.	**48.°** R.
Start cooling	140.° F.	48.° R.	140.° F.	48.° R.	140.° F.	48.° R.
5 minutes	131.° F.	44.° R.	138.2° F.	47.2° R.	138.7° F.	47.4° R.
10 minutes	122.° F.	40° R.	132.8° F.	44.8° R.	131.7° F.	45.6° R.
15 minutes	113.° F.	36° R.	122.° F.	40.° R.	125.9° F.	41.6° R.

OPERATING THE STEAMING APPARATUS.

In the manipulation of a steaming apparatus, the attendant very often, after having properly filled the tank with bottles, and also gradually heated the water, will leave the tank to itself the moment the water shows the desired maximum degree of heat, and attend to other work. When he comes back he finds that the water has considerably cooled. He then again turns on the steam, quickly heats the water and again leaves. This is an improper procedure. It is evident that when the water reaches the maximum temperature, the beer, being then considerably cooler, instantly takes up heat from the water, cooling the latter, and especially the small columns of water between the bottles, *which cool the most* rapidly, since their volume is small in pro

portion to the volume of surrounding beer. In order to dislodge these cooler, stagnant columns of water, the circulation should be kept up continually during the entire time of holding the maximum temperature, and the attendant should stand by, with thermometer in hand, and keep the temperature of the water constant.

In order to hold this temperature automatically an automatic temperature control is now on the market. This is operated by compressed air and has a thermostat, serving to turn on or shut off the air, operating the steam valve by inflating the diaphragm above it.

The water can be safely heated a degree or two above the maximum temperature desired for the beer during the first third or half of the time for holding, since during that time the beer is not warm enough to run the risk of overheating, and, furthermore, in many styles of tanks the water at the top, where the temperature is taken, is generally a degree or two warmer than the water at the bottom, or between the bottles, even when proper circulation is kept up. Care should be taken not to allow the water to rise above the maximum temperature during the last part of the holding period.

The minimum time which the highest temperature, 140° F. (48° R.) should be held is 30 minutes for pints and 45 minutes for quarts, in both cases heating the water gradually to that temperature or slightly above, as described, in 45 minutes.

Tonic or malt extract pints, on account of their somewhat larger diameter, were found, by tests, to require 5 minutes longer heating than export pints.

The cooling can be done as rapidly as the bottles will allow without breaking, but should not be done in less than 20 minutes.

Steaming Caps.—In order that the corks may not be forced out of the bottle by the increased pressure generated during steaming, metal clamps, made of sheet iron, or differently bent wires, are clamped over the necks of the bottles previous to placing them in the tank.

Steaming Trays or Boxes.—As wooden boxes, to hold the bottles during steaming, almost universally present the defects above mentioned, later styles are constructed of galvanized perforated sheet steel, which allows considerable opportunity for water circulation without loss of the necessary rigidity or durability.

Another style consists of a basket made of woven wire, the whole being galvanized.

Whatever style of tray is used, they should never be packed in the tank so as to touch each other at their sides or ends. Even though the spaces may be sufficient, it may happen, if perforated or slotted boxes are placed against each other, that the openings in one box are covered or closed by the solid parts in the next box. A space of at least two inches all around the boxes should be allowed in placing them in the tank.

STEAMING OR PASTEURIZING DEVICES.

The almost universal form of steaming device now in use is the tank consisting of a square or rectangular wooden box, sometimes made of iron, but each style employing a differently constructed heating device or means for circulating the water in the tank or of moving the bottles. The principles underlying their operation are, however, in the main, two: In one type the bottles of beer to be pasteurized remain stationary and the surrounding water is heated, circulated and cooled, and in the other type water having different temperatures is contained in different subdivisions or compartments of the tank and the bottles are passed through them.

Operating on the former principle are the following:

Single Steam-Pipe Tank.—One of the simplest construction of tanks consists of an ordinary wooden tank, having a heating device made on the injector principle. A piece of 3-inch iron pipe, open at both ends, is bolted or clamped to the bottom longitudinally, this pipe being about 18 inches shorter than the tank so that it reaches to about 9 inches from each of the tank ends. At one of the open ends is inserted a smaller steam pipe, extending several inches inward. When the steam is injected into this larger pipe, it draws the cold water in with it, heats it in the tube, and forces it out at the other end warmer than the bulk of the water in the tank, thus causing a circulation as well as heating of the water.

Perforated Steam-Pipe Tank.—In another style the heating device consists of a number of perforated steam pipes branching out from a main supply pipe. Above these pipes a perforated false bottom of wood is placed for the purpose of further distributing the water and holding the bottles.

Upright Steam Injector Tank.—In another, the heating app?

ratus consists of an upright tube, having its steam injector at its lower end, which allows the water to be drawn from all directions toward the center or tube. The water then passes upward, is heated and flows outward again in opposite directions through two series of openings at top of the tube.

Bottom Injector Tank.—Another device employs a central tube injector heating apparatus, but differs from those described in the fact that the steam enters the tube at the top, thus delivering the warmer water to the bottom of the tank, where it spreads and rises among the bottles to the upper part.

Overflow Water.—In all these steam injector heating devices the same water is circulated; that is, the water passes through the injector, is heated, passes out, circulates to where it was taken from, again passes through the injector, is heated somewhat more, etc., etc. The surplus water due to the condensation of the injected steam runs off through an overflow pipe. When it is desired to cool the water, the steam is simply supplanted by cold water, and the cooling and circulation proceed in the same manner as in heating, except that there is more overflow water.

Spiral Conveyor Tank.—Another style accomplishes the mixing of the water by means of a spiral conveyor screw, placed lengthwise through tank at about the center of its depth. The steam heating coil is placed at the bottom, and the cooling pipe for sprinkling cold water is placed at the top. The temperature of the water is equalized by agitating the water by means of the conveyor screw, both during heating and during cooling.

Brass Ejector Tank.—Widely different from the devices above described is one which has for its chief feature a specially constructed brass ejector or pump. To this ejector is connected a system of piping, one branch of which is placed at the bottom of the tank and forms the discharge through which the water, heated or cooled in the ejector is evenly distributed throughout the tank. The other branch of piping is placed outside of and near the top of the tank and is used as an overflow to the water. After the bottles are placed in the tank and this vessel is filled with water to a height sufficient to submerge the return or overflow openings and fill the connecting pipes, steam is turned on. The steam in entering the ejector or pump at once propels the water in it forward, and at the same time heats its. The heated

ter is then forced through the bottom perforated system of ing upward through the water and bottles, thereby slightly sing the temperature of the bulk of water in the tank. As the ited water passes upward, an equal volume of the cooler water m the top of the tank passes downward into the ejector, is re heated, and in turn passes upward as described. This con- uous circulation and gradual heating is kept up automatically :il the desired temperature of the water is obtained. In cooling the water the same manipulation takes place, except that, in- ad of steam, cold water is run through the ejector, whereby : cooling proceeds in the same gradual manner as the heating. little above the return overflow openings another opening is ced, through which an increase in water by condensation of am during heating or injected water during cooling can ape.

The advantages of this system are, first, economy of steam, as live steam whatever enters the tank, but is all absorbed and idensed before being introduced and distributed into the bot- n of the tank. The steam required to operate the pump is small in proportion to the immense amount of water it moves it a sudden rise in temperature and overheating of bottles in impossibility. The cooling of the beer is conducted very rap- y and evenly, no cold water striking the hot bottles to cause equal contraction of the glass and consequently loss by break- : is reduced to a minimum. Another advantage of this sys- n is that the ejector and pipe connections can easily be at- hed to a tank already in place, as they can be made to fit y size or shape of the tank. The ejector is capable of moving m 60 to 100 gallons of water per minute, in proportion to e of tank and apparatus, with moderate steam pressure.

A steaming device employing the second principle, viz., to ve the beer through the water, is of quite recent date.

Water Compartment Pasteurizer.—This apparatus consists of a ig, narrow and shallow tank, subdivided into three smaller iks or compartments, the middle one being the largest. These : filled with water of different temperatures, the first compart- :nt containing water of about one-half the pasteurization tem- rature; the middle, or largest one, water at pasteurization tem- rature, and the last one the same as the first. Over and through : *tank pass two link* belt endless chains, connected by means c

rods, so as to be in appearance more like an endless flexible ladder. To the cross-rods are attached brass wire spring hook clamps for holding the bottles by their necks during their passage through the tank. At the contact between the middle and the end compartments are placed two sprocket pulleys, so that the passage of the bottles through the tank is as follows: The bottles are submerged into the first compartment containing water at about one-half pasteurization temperature, are partly heated and then pass into the middle tank, where the pasteurization takes place. From here the bottles pass into the second attemperating tank, where they are partially cooled. After emerging from this place they are further cooled, and at the same time rinsed by a spray of water.

The advantages claimed for this tank are the following: A saving of labor, as only two boys are necessary to load and unload the racks; the regularity of the pasteurization process, each bottle receiving exactly the same treatment as the next; the smaller percentage of loss by breakage, due to the fact that the temperature in the various baths can be controlled and sudden variations of temperature thus prevented. Another advantage, which is a considerable one in the cost of operating the bottle shop, lies in the fact that the water in this tank is not heated, cooled and run out at each steaming, preventing a waste of water and fuel. The water remains the same, and all the heat and water that must be supplied is only such as is lost by radiation and evaporation, which is comparatively little, and that heat absorbed by the beer.

FINISHING THE PACKAGE.

BOTTLE LABELING.

Even though all the necessary precautions may have been taken, in both the brewery and bottle shop, for the production of a sound and durable bottle beer, there still remains another feature which quite often considerably influences the product's popularity, or often unjustly enhances or detracts from its quality in the imagination of the consumer. This is the general appearance of the bottle or package as put upon the market, which is generally determined by the style of label and cap, or the neatness with which these are affixed. This is especially the case with export or "shipping" bottle beer, which quite often finds its way

into the hands of distant consumers possessing little or no judgment as to quality, and who, if they are not influenced in their choice by the reputation of the brewer, are entirely so by the appearance of the package, preferring those which are nicely put up.

In most bottle shops the labeling of the bottles is still done by hand, which offers many drawbacks as to neatness and economy. Such work may be defective in that, if performed by a careless workman, even though a fine label be used, the neat appearance of the bottle can greatly be detracted from by his pasting on the labels in a crooked position, at unequal heights on different bottles, or by smearing paste upon the label or bottle.

In order to overcome these defects and to lessen the time necessary to affix the labels, machines for that purpose are now used in many of the larger bottling departments, which, by the uniformity and speed so far attained, certainly recommend their general use.

The principle of operation of the different labeling machines now on the market is very much the same, and in a general way is the following: The labels are held in large numbers by a label plate or holder, from which they are taken one by one by a picker and placed upon the bottle. This picker, before taking up a label, passes over a roller, or other device, holding paste, by contact with which it is covered with the proper amount of paste, and transfers it by contact to the label, which it picks up. When the label touches the bottle the pickers are disengaged and the pressure necessary to tighten the label is supplied by a set of rubber wipers. These are similar to the well-known window-cleaners, and in their action much resemble the wiping done by hand. The whole operation is automatic; all that the operator need do is to have a bottle in position when the picker and label come toward it. The bottle rest is adjustable as to the depth to which the bottle can be inserted, thereby regulating the height at which the label is put on the bottle. The rest is also adjustable as to height, so that bottles of different diameters can be centered.

The general advantages to be derived from the use of automatic labeling machines are: Speed of operation, no experience of operator being necessary to properly run machine; cleanliness of finished bottle, since no paste can get upon the label or the hands

of the operator; labels are all affixed uniformly; that is, at equal height from, and with lower edge parallel to, bottom of bottle, or if slanting labels are used, the slant on all labels is of the same angle.

CAPPING.

Although but a slight expense for each bottle, a cap of tin foil greatly adds to the finished appearance of the package. It has a further advantage, in that it protects the lip of the bottle from dirt or other matter settling on it after the bottle has stood in an upright position for some time. As this dirt is not removed by the drawing of a cork or the removing of a seal, it sometimes happens that it is washed into the glass while pouring out the contents of the bottle.

STORAGE AND DELIVERY.

The proper storage of bottled beer is of as great importance as any of the manipulations to produce it.

Light. Beer contained in white or clear glass bottles should never be exposed to direct light as it will quickly deteriorate in flavor and brilliancy.

Patent stopper or unsteamed beer should be stored cold, that is, the same as beer in kegs.

Pasteurized beer, on the other hand, should not be stored too cold, but preferably at ordinary room temperatures.

Corks.—Bottles closed with corks should not be stored in an upright position, but lying upon their sides so that the corks will be moistened by the beer and prevented from drying out, which would permit the escape of gas.

PIPE LINES.

In larger breweries the filling from barrels, which entails the troublesome operations of taking care of the packages—filling, cleaning, pitching, stamping, etc.—is being replaced by filling from government casks, connected by pipe line from the chip casks directly.

Here the casks or tanks, placed in a separate refrigerated room under the bottle shop, are filled and gauged under control of a government inspector.

This system has the advantage of rapidity—saving the repeated *tapping of* barrels—also a more uniform delivery, besides a *saving of labor* in the general handling of the beer. (See "*Legal Relations.*")

FIGURING IN THE BREWERY.

(Temperatures in this chapter are given in degrees Reaumur only because calculations are simpler than with Fahrenheit degrees, and the Reaumur thermometer is more generally employed for these purposes in American breweries.)

CALCULATING THE YIELD OF EXTRACT OF BREWING MATERIALS.

By "yield of extract." or "yield" simply, is meant the number of pounds of extract which is obtained from 100 pounds of a material used in brewing.

The yield is, therefore, always given in per cent. Thus, if we say the yield of a malt is 64 per cent, or a malt yields 64 per cent of extract, we mean that we obtain 64 pounds of extract from 100 pounds of malt.

In order to calculate the yield of extract of a material we should know:

1. Balling (B.), i. e., the saccharometer (Balling) indication of the wort in the cellar or in the kettle at 14° R.
2. Specific gravity (Sp. G.) of the wort.
3. Bbls., i. e., the number of barrels of wort in the cellar or in the kettle.
4. Materials, i. e., the amount of material used, in pounds.

In order to find the number of pounds of extract obtained from 100 pounds of material, i. e., to calculate the yield, we must first figure out how many pounds of extract were obtained altogether from the total materials used, i. e., how many pounds of extract are contained in the total wort. This is done as follows:

FIGURING EXTRACT IN TOTAL WORT.

The weight of a barrel of water at cellar temperature (4° R.) is 258.5 pounds. The weight of a barrel of wort of a certain Balling indication is 258.5 × sp. g.

Since the Balling indication of a wort (B.) shows how many pounds of extract are contained in 100 pounds of wort, it follows that

$$\text{Extract in 1 bbl. wort} = \frac{258.5 \times \text{sp. g.} \times \text{B.}}{100}.$$

Hence

$$\text{Total extract in wort} = \frac{258.5 \times \text{sp. g.} \times \text{B.} \times \text{bbls.}}{100}.$$

This being the extract obtained from the total materials, the extract from 100 pounds, or the

$$\text{Yield} = \frac{258.5 \times \text{sp. g.} \times \text{B.} \times \text{bbls.}}{\text{Total materials}}.$$

Example 1.—6,600 pounds malt yield 120 barrels wort in cellar at 13 per cent B.; sp. g. 1.053. What is the yield of the malt?

Solution.—

$$\text{Yield} = \frac{258.5 \times 1.053 \times 13 \times 120}{6600}.$$

$$= \frac{424632}{6600}$$

$$= 64.3.$$

Answer.—Yield = 64.3 per cent.

A table of Specific Gravity and Balling will be found in "The Brewers' Chemical Laboratory," and one for reducing Balling indications to pounds of extract per barrel on the next page.

CALCULATIONS ACCORDING TO R. WAHL.

ABRIDGED CALCULATION OF YIELD BY WAHL'S FORMULA.

To calculate the yield by the above method involves consulting a table for the specific gravity and a tedious multiplication by that figure. Both of these inconveniences are avoided by using Wahl's formula. Wahl found that if the Balling indication of a wort *is added to 259*—which is sufficiently accurate for the weight of a *barrel of* water at cellar temperature—the result will be the weight

BALLING READING IN POUNDS OF EXTRACT PER BARREL.

Balling's Saccharometer, Per Cent.	Pounds Extract Per Barrel.	Balling's Saccharometer, Per Cent.	Pounds Extract Per Barrel.	Balling's Saccharometer, Per Cent.	Pounds Extract Per Barrel.	Balling's Saccharometer, Per Cent.	Pound Extracts Per Barrel.
1.00	2.60	6.8	18.06	12.6	34.25	18.4	51.19
1.1	2.85	6.9	18.33	12.7	34.52	18.5	51.48
1.2	3.12	**7.0**	18.60	12.8	34.81	18.6	51.78
1.3	3.38	7.1	18.88	12.9	35.10	18.7	52.08
1.4	3.63	7.2	19.15	**13.0**	35.38	18.8	52.39
1.5	3.90	7.3	19.42	13.1	35.67	18.9	52.68
1.6	4.16	7.4	19.70	13.2	35.96	**19.0**	52.98
1.7	4.42	7.5	19.97	13.3	36.25	19.1	53.29
1.8	4.68	7.6	20.25	13.4	36.53	19.2	53.59
1.9	4.94	7.7	20.52	13.5	36.82	19.3	53.90
2.0	5.21	7.8	20.79	13.6	37.11	19.4	54.20
2.1	5.47	7.9	21.07	13.7	37.39	19.5	54.49
2.2	5.74	**8.0**	21.35	13.8	37.68	19.6	54.80
2.3	6.00	8.1	21.72	13.9	37.97	19.7	55.10
2.4	6.26	8.2	21.90	**14.0**	38.26	19.8	55.40
2.5	6.58	8.3	22.17	14.1	38.55	19.9	55.70
2.6	6.79	8.4	22.48	14.2	38.84	**20.0**	56.00
2.7	7.05	8.5	22.73	14.3	39.13	20.1	56.30
2.8	7.32	8.6	23.00	14.4	39.41	20.2	56.61
2.9	7.58	8.7	23.28	14.5	39.70	20.3	56.91
3.0	7.85	8.8	23.56	14.6	40.00	20.4	57.21
3.1	8.11	8.9	23.88	14.7	40.28	20.5	57.52
3.2	8.38	**9.0**	24.11	14.8	40.57	20.6	57.82
3.3	8.64	9.1	24.39	14.9	40.87	20.7	58.13
3.4	8.91	9.2	24.67	**15.0**	41.15	20.8	58.43
3.5	9.17	9.3	24.94	15.1	41.45	20.9	58.74
3.6	9.44	9.4	25.22	15.2	41.73	**21.0**	59.04
3.7	9.70	9.5	25.50	15.3	42.03	21.1	59.35
3.8	9.97	9.6	25.78	15.4	42.32	21.2	59.66
3.9	10.24	9.7	26.06	15.5	42.61	21.3	59.96
4.0	10.50	9.8	26.33	15.6	42.91	21.4	60.27
4.1	10.77	9.9	26.61	15.7	43.20	21.5	60.57
4.2	11.04	**10.0**	26.89	15.8	43.49	21.6	60.88
4.3	11.31	10.1	27.18	15.9	43.78	21.7	61.19
4.4	11.57	10.2	27.46	**16.0**	44.08	21.8	61.49
4.5	11.84	10.3	27.73	16.1	44.37	21.9	61.80
4.6	12.11	10.4	28.01	16.2	44.66	**22.0**	62.11
4.7	12.38	10.5	28.29	16.3	44.96	22.1	62.42
4.8	12.64	10.6	28.58	16.4	45.25	22.2	62.73
4.9	12.91	10.7	28.86	16.5	45.55	22.3	63.04
5.0	13.18	10.8	29.14	16.6	45.84	22.4	63.35
5.1	13.45	10.9	29.42	16.7	46.13	22.5	63.65
5.2	13.72	**11.0**	29.70	16.8	46.43	22.6	63.96
5.3	14.00	11.1	30.00	16.9	46.72	22.7	64.27
5.4	14.26	11.2	30.27	**17.0**	47.02	22.8	64.58
5.5	14.53	11.3	30.45	17.1	47.32	22.9	64.89
5.6	14.80	11.4	30.83	17.2	47.61	**23.0**	65.20
5.7	15.07	11.5	31.10	17.3	47.91	23.1	65.50
5.8	•15.34	11.6	31.[illegible]	17.4	48.21	23.2	65.82
5.9	15.61	11.7	31.68	17.5	48.50	23.3	66.14
6.0	15.88	11.8	31.87	17.6	48.80	23.4	66.45
6.1	16.15	11.9	32.13	17.7	49.10	23.5	66.76
6.2	16.42	**12.0**	32.53	17.8	49.40	23.6	67.08
6.3	16.69	12.1	32.83	17.9	49.69	23.7	67.38
6.4	16.97	12.2	33.10	**18.0**	50.00	23.8	67.70
6.5	17.25	12.3	33.39	18.1	50.29	23.9	68.01
6.6	17.51	12.4	33.67	18.2	50.78	**24.0**	68.32
6.7	17.78	12.5	33.95	18.3	51.08		

of a barrel of wort of the given Balling indication. Wahl's formula reads as follows:

$$\text{Yield} = \frac{(259 + \text{B.}) \times \text{B.} \times \text{bbls.}}{\text{materials}}.$$

By this abridged formula the following values can be calculated:

1. Weight of 1 bbl. wort $= 259 + \text{B}$.
2. Lbs. extract in 1 bbl. wort $= \dfrac{(259 + \text{B}) \times \text{B}}{100}$.
3. Lbs. total extract in total wort $= \dfrac{(259 + \text{B}) \times \text{B} \times \text{bbls.}}{100}$.
4. Yield as above.

Example 2.—Same as in 1; 6,600 pounds of material give 120 barrels of wort in cellar at 13 per cent Balling. What is the yield?

Solution.—

$$\text{Yield} = \frac{(259 + 13) \times 13 \times 120}{6600}.$$

$$= \frac{424320}{6600}$$

$$= 64.3.$$

Answer.—Yield = 64.3 per cent, or, the same result as above.

CALCULATING YIELD FOR TWO DIFFERENT MATERIALS.

If two different materials are used together (malt and raw cereals), the total yield of mixed materials, or the average yield, is calculated the same as above. But if it is desired to find the yield of one of the two materials, for instance, the raw cereal, it is necessary to know the yield of the other, for instance, the malt. If an approximate value is sufficient for the purpose in hand, the average yield of a malt of the quality in question is taken. To be accurate, it is better to take the yield obtained in a pure malt brewing.

Example 1.—A brewing with 3,500 pounds of malt and 1,900 pounds of raw cereals, gives 95 barrels of wort in the cellar at 14 per cent Balling. The yield of the malt in a pure malt brewing was 63 per cent. What is the yield of the raw cereal?

Solution.—First figure out the total extract from the total material:

$$\text{Total extract} = \frac{(259 + 14) \times 14 \times 95}{100}.$$

$$= 3630.9 = 3631.$$

We have, therefore, 3631 pounds extract from the total material.

Next, calculate the extract from the malt:

100 lbs. malt yield = 63 lbs. extract.
3500 lbs. malt yield ? lbs. extract.

$$\frac{3500 \times 63}{100} = 2205.$$

We have, therefore, 2205 pounds malt extract.

Deducting the malt extract from the total extract, gives the extract from the raw cereal:

3631 lbs. total extract.
2205 lbs. malt extract.

1426 lbs. raw cereal extract.

This amount of extract was obtained from 1900 lbs. raw cereal, hence

1900 lbs. raw cereal yield 1426 lbs. extract.
100 lbs. raw cereal yield ? lbs. extract.

$$\frac{1426 \times 100}{1900} = 75.$$

Answer.—Yield of extract from raw cereal = 75 per cent.

Example 2.—6500 pounds of material, consisting of 60 per cent malt and 40 per cent grits, give 130 barrels of wort in the cellar at 12.5 per cent Balling. The malt yield is 63 per cent. What is the yield of the grits?

There are two ways of solving this example.

Solution 1.—First calculate the number of pounds of malt and grits used, respectively.

100 lbs. materials contain 60 lbs. malt.
6500 lbs. materials contain ? lbs. malt.

$$\frac{6500 \times 60}{100} = 3900 \text{ lbs. malt.}$$

6500 lbs. total materials
less 3900 lbs. malt

gives 2600 lbs. grits.

Calculate as above:

$$\text{Total extract} = \frac{(259 + 12.5) \times 12.5 \times 130}{100}$$

$$= \frac{3393.75 \times 130}{100}$$

$$= \frac{441187}{100}$$

$$= 4411.9, \text{ or } 4412.$$

100 lbs. malt yield 63 lbs. extract.
3900 lbs. malt yield ? lbs. extract.

$$\frac{3900 \times 63}{100} = 2457 \text{ lbs. malt extract.}$$

4412 lbs. total extract
subtract 2457 lbs. malt extract

leaves 1955 lbs. grits extract from 2600 lbs. grits.

2600 lbs. grits yield 1955 lbs. extract.
100 lbs. grits yield ? lbs. extract.

$$\frac{1955 \times 100}{2600} = 75.2.$$

Answer.—Yield of grits = 75.2 per cent.

Solution 2.—Calculate the average yield of the mixed materials:

$$\text{Yield of mixed materials} = \frac{(259 + 12.5) \times 12.5 \times 130}{6500}$$

$$= \frac{441187}{6500}$$

$$= 67.8.$$

The average yield is 67.8 per cent, i. e., 100 lbs. mixed materials yield 67.8 lbs. extract; 100 lbs. mixed materials consist of 60 lbs. malt and 40 lbs. grits. Deduct the extract of 60 lbs. malt

from 67.8 lbs. extract, and the result will be the extract of 40 lbs. grits:

100 lbs. malt yield 63 lbs. extract.
60 lbs. malt yield ? lbs. extract.

$$\frac{63 \times 60}{100} = 37.8 \text{ lbs. malt extract.}$$

67.8 lbs. extract from 60 lbs. malt and 40 lbs. grits
less 37.8 lbs. extract from 60 lbs. malt alone

gives 30.0 lbs. extract from 40 lbs. grits.

40 lbs. grits yield 30 lbs. extract.
100 lbs. grits yield ? lbs. extract.

$$\frac{30 \times 100}{40} = 75.$$

Answer.—Grits yield = 75 per cent.

CALCULATING YIELD IN THE KETTLE.

For many purposes it is desirable to calculate the yield from the material by the total amount of wort in the kettle and the Balling indication of such wort.

Since the wort in the kettle is at a boil, the figure 259 for the weight of a barrel of water at cellar temperature cannot be used, but the weight of a barrel of boiling water must be taken, which is approximately 246 lbs. For calculating the yield of extract in the kettle, Wahl's formula, therefore, takes this appearance:

$$\text{Yield} = \frac{(246 + \text{B}) \times \text{B} \times \text{bbls.}}{\text{materials}}.$$

Example.—8800 pounds of material is used, from which 200 barrels of wort in the kettle of 12 per cent Balling is obtained. What is the yield of extract?

Solution.—

$$\text{Yield} = \frac{(246 + 12) \times 12 \times 200}{8800}$$

$$= \frac{619200}{8800}$$

$$= 70.36.$$

Answer.—Yield = 70.36 per cent.

CALCULATING CONCENTRATION OF WORT IN KETTLE.

On leaving the mash-tun and running into the kettle the wort shows a certain per cent Balling, which is considerably below that required when the wort leaves the kettle. In order to concentrate the wort to the required density a certain amount of water must be drawn off by evaporation in boiling.

The question is, how much should be evaporated, or how much should the wort be boiled down?

The answer is found by the following formula:

$$\left.\begin{array}{l}\text{Bbls. wort}\\ \text{after boiling}\end{array}\right\} = \frac{\text{Bbls. of wort before boil.} \times \text{Balling before boil.}}{\text{Balling after boiling}}$$

Example.—A sample of wort from the kettle after being cooled to 14° R. shows 12 per cent Balling. It is required to have a wort of 13 per cent Balling, when running from kettle. How much should the wort be boiled down in the kettle, the total amount of wort on hand being 320 barrels?

Solution.—Bbls. wort after boiling $= \frac{320 \times 12}{13} = 295.4$, consequently the 320 barrels of wort must be boiled down to 295.4 barrels.

$$320 - 295.4 = 24.6.$$

Answer.—Amount of water to be evaporated = 24.6 barrels.

CALCULATING THE MATERIALS.

If the question is, how many pounds of material are required to produce a given number of barrels of wort of a certain Balling indication, the yield of the material should be known. The formula for this calculation is as follows:

$$\text{Materials in lbs.} = \frac{(259 + \text{B}) \times \text{B} \times \text{bbls.}}{\text{Yield.}}.$$

MALT.

Example 1.—How many pounds of malt will be required for a brewing of 150 barrels in the cellar at 13.8 per cent Balling, the malt yield being 64 per cent?

Solution.—

$$\text{Materials} = \frac{(259 + 13.8) \times 13.8 \times 150}{64}$$

$$= \frac{564696}{64}$$

$$= 8823$$

Answer.—Required: 8823 lbs. malt.

MALT AND RAW CEREALS.

Example 2.—How many pounds of malt and how many pounds of grits are required for 300 barrels in the cellar at 12.5 per cent Balling, using 65 per cent of malt and 35 per cent of grits, the yield of malt being 64 per cent, of grits 75 per cent?

Solution.—

1. Calculate the average yield:

100 lbs. malt yield 64 lbs. extract.
65 lbs. malt yield ? lbs. extract.

$$\frac{64 \times 65}{100} = 41.6 \text{ lbs. malt extract.}$$

100 lbs. grits yield 75 lbs. extract.
35 lbs. grits yield ? lbs. extract.

$$\frac{75 \times 35}{100} = 26.2 \text{ lbs. grits extract.}$$

65 lbs. malt yield 41.6 lbs. extract.
35 lbs. grits yield 26.2 lbs. extract.

100 lbs. mixed yield 67.8 lbs. extract.

Answer.—Average yield = 67.8 per cent.

2. Calculate the total materials:

$$\text{Total material} = \frac{(259 + \text{B}) \times \text{B} \times \text{Bbls.}}{\text{Yield}}.$$

$$= \frac{(259 + 12.5) \times 12.5 \times 300}{67.8}$$

$$= \frac{101812.5}{67.8}$$

$$= 15016.$$

Total *materials required* = 15016 lbs.

MATERIALS USED TO PRODUCE ONE BARREL OF WORT OF DIFFERENT GRAVITIES IN THE CELLAR. MALT RECKONED AT 64 PER CENT, YIELD OF ADJUNCTS AS PER HEADING.

Per Cent Balling of Wort.	Extract in 1 Barrel of Wort, Lbs.	Malt Employed, Lbs.	Yield of Adjunct: 75%.						Yield of Adjunct: 80%.						Yield of Adjunct: 90%.					
			75% Malt.		66⅔% Malt.		60% Malt.		75% Malt.		66⅔% Malt.		60% Malt.		75% Malt.		66⅔% Malt.		60% Malt.	
			Malt Lbs.	Adjt Lbs.	Malt Lbs.	Adjt Lbs.	Malt Lbs.	Adjt Lbs.	Malt Lbs.	Adjt Lbs.	Malt Lbs.	Adjt Lbs.	Malt Lbs.	Adjt Lbs.	Malt Lbs.	Adjt Lbs.	Malt Lbs.	Adjt Lbs.	Malt Lbs.	Adjt Lbs.
10.00	26.90	42.03	30.23	10.07	26.50	13.25	23.60	15.73	29.67	9.89	25.87	12.93	22.93	15.28	28.62	9.54	24.67	12.34	21.69	14.46
10.50	28.30	44.22	31.80	10.60	27.88	13.94	24.82	16.55	31.21	10.41	27.21	13.61	24.12	16.08	30.10	10.04	25.95	12.98	22.82	15.21
11.00	29.70	46.40	33.38	11.12	29.25	14.63	26.06	17.37	32.76	10.92	28.56	14.28	25.31	16.88	31.60	10.53	27.23	13.62	23.95	15.96
11.25	30.41	47.51	34.17	11.39	29.95	14.98	26.68	17.78	33.54	11.18	29.24	14.62	25.92	17.28	32.35	10.78	27.89	13.94	24.52	16.34
11.50	31.11	48.60	34.96	11.65	30.65	15.32	27.29	18.19	34.31	11.44	29.91	14.96	26.51	17.68	33.10	11.03	28.53	14.26	25.09	16.73
11.75	31.82	49.71	35.75	11.92	31.34	15.67	27.91	18.61	35.09	11.70	30.60	15.30	27.12	18.08	33.85	11.28	29.18	14.59	25.66	17.10
12.00	32.52	50.81	36.54	12.18	32.03	16.02	28.52	19.02	35.86	11.96	31.27	15.64	27.71	18.48	34.60	11.53	29.83	14.92	26.23	17.48
12.25	33.23	51.92	37.34	12.45	32.73	16.37	29.15	19.43	36.65	12.22	31.95	15.98	28.32	18.88	35.35	11.78	30.49	15.24	26.80	17.86
12.50	33.94	53.03	38.14	12.71	33.43	16.72	29.77	19.85	37.43	12.48	32.63	16.32	28.93	19.28	36.10	12.04	31.13	15.57	27.37	18.25
12.75	34.65	54.14	38.93	12.98	34.13	17.07	30.39	20.26	38.21	12.74	33.32	16.66	29.53	19.69	36.86	12.29	31.79	15.89	27.95	18.63
13.00	35.36	55.25	39.73	13.24	34.83	17.42	31.01	20.68	39.00	13.00	34.00	17.00	30.14	20.09	37.62	12.54	32.44	16.22	28.52	19.01
13.25	36.07	56.36	40.53	13.51	35.53	17.77	31.64	21.09	39.78	13.26	34.68	17.34	30.74	20.49	38.37	12.79	33.09	16.55	29.09	19.40
13.50	36.79	57.39	41.34	13.78	36.23	18.12	32.27	21.51	40.57	13.53	35.37	17.69	31.35	20.90	39.13	13.05	33.75	16.88	29.67	19.78
13.75	37.50	58.60	42.14	14.04	36.93	18.47	32.89	21.93	41.35	13.79	36.05	18.03	31.96	21.30	39.89	13.30	34.41	17.20	30.24	20.16
14.00	38.22	59.72	42.96	14.31	37.65	18.82	33.52	22.35	42.15	14.05	36.75	18.37	32.57	21.71	40.66	13.55	35.07	17.53	30.82	20.55
14.25	38.94	60.85	43.76	14.58	38.35	19.18	34.15	22.77	42.94	14.32	37.44	18.72	33.18	22.12	41.42	13.81	35.73	17.86	31.40	20.94
14.50	39.66	61.97	44.57	14.85	39.06	19.53	34.78	23.19	43.74	14.58	38.13	19.07	33.80	22.53	42.19	14.06	36.39	18.19	31.99	21.32
14.75	40.38	63.09	45.38	15.12	39.77	19.89	35.42	23.61	44.53	14.85	38.83	19.41	34.41	22.94	42.95	14.32	37.05	18.52	32.56	21.71
15.00	41.11	64.23	46.19	15.40	40.50	20.25	36.06	24.04	45.34	15.11	39.53	19.76	35.03	23.36	43.73	14.58	37.71	18.86	33.16	22.10
15.50	42.55	66.48	47.81	15.94	41.92	20.96	37.33	24.88	46.93	15.64	40.91	20.46	36.26	24.18	45.26	15.09	39.03	19.52	34.32	22.88
16.00	44.00	68.75	49.44	16.48	43.33	21.67	38.60	25.73	48.52	16.18	42.31	21.15	37.50	25.00	46.81	15.60	40.37	20.18	35.49	23.66
16.50	45.46	71.03	51.08	17.03	44.77	22.39	39.88	26.58	50.14	16.71	43.71	21.86	38.74	25.83	48.36	16.12	41.71	20.85	36.67	24.44
17.00	46.92	73.32	52.73	17.57	46.21	23.11	41.15	27.44	51.75	17.25	45.11	22.56	39.99	26.66	49.91	16.64	43.05	21.52	37.84	25.23
17.50	48.39	75.61	54.38	18.12	47.67	23.83	42.44	28.30	53.37	17.79	46.53	23.26	41.24	27.50	51.48	17.16	44.39	22.20	39.02	26.02
18.00	49.86	77.91	56.03	18.67	49.12	24.56	43.73	29.16	54.99	18.33	47.94	23.97	42.49	28.33	53.05	17.68	45.75	22.87	40.21	26.81

3. **Calculate the pounds of malt and grits.**

100 lbs. materials contain 65 lbs. malt.
15016 lbs. materials contain ? lbs. malt.

$$\frac{15016 \times 65}{100} = 9760 \text{ lbs. malt.}$$

15016 lbs. total materials.
9760 lbs. malt.

5256 lbs. grits.

Answer.—Required: 9750 lbs. malt and 5256 lbs. grits.

CALCULATING THE COST.

To calculate the cost of a barrel of wort (in cellar) as far as the required material is concerned, the following values must be known:

1. Saccharometer indication of the wort in cellar.
2. Percentage of each material of the total.
3. Yields of the materials.
4. Cost of the materials.

This calculation will be illustrated by the following:

Example.—A wort of 13.5 per cent Balling in the cellar is to be prepared from 60 per cent malt, 40 per cent rice, and 1.5 lbs. hops per barrel. What is the cost of the materials per barrel at the following prices: Malt 58 cents per bushel of 33 lbs., rice 210 cents per 100 lbs., and hops 18.5 cents per pound. Yield of the malt 64 per cent, of the rice 78 per cent?

Solution.—Find the amount of materials required for a barrel of wort, as above.

Calculation of average yield:

100 lbs. malt yield 64 lbs. extract.
60 lbs. malt yield ? lbs. extract.

$$\frac{60 \times 64}{100} = 38.4 \text{ lbs. malt extract.}$$

100 lbs. rice yield 78 lbs. extract.
40 lbs. rice yield ? lbs. extract.

$$\frac{78 \times 40}{100} = 31.2 \text{ rice extract.}$$

60 lbs. malt yield 38.4 lbs. extract.
40 lbs. rice yield 31.2 lbs. extract.

100 lbs. mixed yield 69.6 lbs. extract.

Calculation of total materials:

$$\text{Total materials for one barrel} = \frac{(259 + 13.5) \times 13.5}{69.6}$$

$$= \frac{3678.75}{69.6}$$

$$= 52.9.$$

Total materials required 52.9 lbs. of which 60 per cent malt and 40 per cent rice.

In 100 lbs. materials 60 lbs. malt.
In 52.9 lbs. materials ? lbs. malt.

$$\frac{52.9 \times 60}{100} = 31.74 \text{ lbs. malt.}$$

52.9 lbs. total materials
less 31.7 lbs. malt

gives 21.2 lbs. rice.

The materials required for a barrel of wort, therefore, are:

31.7 lbs. malt.
21.2 lbs. rice.
1.5 lbs. hops.

The cost of these materials is found in the following manner:

1. Malt.

33 lbs. malt cost 58 cents.
31.7 lbs. malt cost ? cents.

$$\frac{31.7 \times 58}{33} = 55.7.$$

Cost of malt = 55.7 cents.

2. Rice.

100 lbs. rice cost 210 cents.
21.2 lbs. rice cost ? cents.

$$\frac{21.2 \times 210}{100} = 44.5.$$

Cost of rice = 44.5 cents.

3. Hops.

1	lb.	hops cost	18.5	cents.
1.5	lbs.	hops cost	?	cents.

$$18.5 \times 1.5 = 27.7.$$

Cost of hops = 27.7 cents.

In conclusion

the malt cost..................	55.7 cents.
the rice cost..................	44.5 cents.
the hops cost..................	27.7 cents.
Total materials cost......	127.9 cents.

Answer.—The cost of the materials per barrel of wort amounts to $1.27.

FIGURING COST OF ONE BARREL OF BEER.

If we want to find the cost of material used in producing a barrel of beer ready for delivery we must add to the cost of a barrel of wort as figured above the cost of the beer lost between starting tub and racking bench. (See "Losses from Malt Mill to Racking Bench.")

Example.—If 100 barrels of wort in starting tub equal 95 barrels marketable beer (loss 5 per cent), and the cost of the material for the production of one barrel of wort is $1.27 what would be the cost of a barrel of beer?

Solution.—If 95 barrels of beer are obtained from 100 barrels of wort it takes $\frac{100}{95} = 1.05$ barrel of wort to obtain one barrel of beer.

Since one barrel of wort costs $1.27, 1.05 barrels of wort cost $1.05 \times 1.27 = \$1.33$.

Answer.—Cost of material for one barrel of beer $1.33.

CALCULATING THE MATERIALS ACCORDING TO M. SCHWARZ.

In figuring out the amounts of malt and adjuncts required for a brewing, the percentage of yield of extract from the various materials should be first determined. Average values for yields are given in the following tables:

1 bu. uncleaned malt = 34 lbs.
1 bu. cleaned malt = 33 lbs.

1 bu. cleaned malt yields........	21	pounds of extract
100 lbs. cleaned malt yields.........	63.6	pounds of extract
100 lbs. corn (fine) yields..........	76	pounds of extract
100 lbs. flakes yields................	78	pounds of extract
100 lbs. rice yields..................	82	pounds of extract
100 lbs. glucose or grape sugar yields	79	pounds of extract
100 lbs. anhydrous grape sugar yields	97	pounds of extract
100 lbs. cane sugar yields...........	100	pounds of extract

One bushel of malt is replaced by

27.63 lbs. corn.
26.92 lbs. flakes.
25.61 lbs. rice.
26.58 lbs. glucose or grape sugar.
21.6 lbs. anhydrous grape sugar.
21.0 lbs. cane sugar.

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100 lbs. corn takes the place of..........	3.62 bu. malt.
100 lbs. flakes takes the place of........	3.7 bu. malt.
100 lbs. rice takes the place of..........	3.9 bu. malt.
100 lbs. glucose or grape sugar takes the place of	3.8 bu. malt.
100 lbs. anhydrous grape sugar takes the place of	4.62 bu. malt.
100 lbs. cane sugar takes the place of....	4.76 bu. malt.

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100 lbs. corn takes the place of....	119.5 lbs. cleaned malt.
100 lbs. flakes takes the place of....	122.6 lbs. cleaned malt.
100 lbs. rice takes the place of....	128.9 lbs. cleaned malt.
100 lbs. glucose or grape sugar takes the place of..................	124.2 lbs. cleaned malt.
100 lbs. anhydrous grape sugar takes the place of..................	152.5 lbs. cleaned malt.
100 lbs. cane sugar takes the place of	157.2 lbs. cleaned malt.
10 gal. syrup takes the place of..	147 lbs. cleaned malt.

Inserting the respective values from the above tables in the *formulas given* below, the amount of materials for a brewing can *be readily* calculated.

ALL MALT.

The question is: How many bushels of malt are required in order to obtain a certain number of barrels of wort of a given percentage of extract, either in the kettle or in the fermenter?

Let B = the bushels of malt to be found,
W = the barrels of wort,
p = percentage of extract in the wort,
F = a factor which is equal 125 for wort in the kettle and 133 for wort in the fermenter, taking an average malt yield of 60 per cent. Should the yield not be 60 per cent, deduct 2 from the factor F for each per cent above 60, and add 2 to the factor F for each per cent below 60.

The formula then is:

$$B = \frac{W \times p \times F}{1000}.$$

Example 1.—How many bushels of malt are required to get 165 barrels of wort of 12.8 per cent extract in the fermenting cellar, the malt yield being 60 per cent?

Solution.—

$$W = 165, \; F = 133, \; p = 12.8.$$

$$B = \frac{165 \times 12.8 \times 133}{1000} = \frac{280896}{1000} = 280.9.$$

Answer.—The required amount of malt is 280.9, or nearly 281 bushels.

Example 2.—How many bushels of malt are required to get in the kettle 200 barrels of wort of 13 per cent Balling, the malt yield being 62 per cent?

Solution.—

$$W = 200, \; p = 13, \; F = 125 - (2 \times 2) = 121.$$

$$B = \frac{200 \times 13 \times 121}{1000} = \frac{314600}{1000} = 314.6.$$

Answer.—The required amount of malt is 314.6 bushels.

MALT AND ADJUNCTS.

If adjuncts are to be used with malt, calculate first the amount of malt that would be required if the brewing were to be made *of all malt, after which* replace the desired portion of the figur

for malt by the adjunct that is to be used, inserting the values given in the tables above.

Example 1a.—Taking Example 1, above, under "All Malt," and saying that 30 per cent of the materials is to be replaced by flakes, what amounts of malt and flakes would be required?

Solution.—Total materials if malt alone was to be used would be 280.9 bushels, as calculated above. Of this amount 30 per cent is:

$$\frac{280.9 \times 30}{100} = 84.3 \text{ bushels (approximately).}$$

This amount is to be replaced with flakes. One bushel of malt is replaced by 26.92 pounds of flakes. Hence, multiply 26.92 by 84.3.

$$26.92 \times 84.3 = 2269.3$$

The amount of flakes to be taken is 2,269.3, or in round numbers 2,270 pounds. The quantity of malt is to be reduced 30 per cent.

Hence,

$$280.9 - 84.3 = 196.6$$

is the amount of malt to be used.

Answer.—2,270 pounds of flakes and 196.6 bushels of malt is the required amount of materials.

Example 1b.—Still taking Example 1 (above), under "All Malt," and saying 20 per cent of the malt is to be replaced by corn grits and 20 per cent by grape sugar. What amounts of malt, grits and grape sugar are required?

Solution.—The required amount of malt, if an all-malt brewing was intended, as calculated above, would be 280.9. Of this amount 40 per cent is:

$$\frac{280.9 \times 40}{100} = 112.4 \text{ (approximately).}$$

Half of this amount = 56.2 bushels is to be replaced by corn grits, and the other half by grape sugar. There remains malt

$$280.9 - 112.4 = 168.5 \text{ bu.}$$

One bushel of malt is replaced by 27.63 pounds of corn. Hence, the amount of corn required is

$$27.63 \times 56.2 = 1553 \text{ lbs.}$$

in round numbers.

One bushel of malt is replaced by 26.58 pounds of grape sugar.

Hence, the amount of grape sugar required is

$$56.2 \times 26.58 = 1494 \text{ lbs.}$$

in round numbers.

Answer.—The required amount of materials is 168.5 bushels of malt, 1,553 pounds of grits and 1,494 pounds of grape sugar.

MATERIALS ADDED IN KETTLE.

Where grape sugar, glucose or other adjuncts are used, which are directly soluble and are added in the kettle, another formula may be used.

The question here is, what amount of glucose, syrup or sugar of any kind, of known yield, should be added in the kettle in order to raise the percentage of extract in a given number of barrels of wort to a certain figure?

Let $W =$ the barrels of wort,
$p =$ the percentage of extract in the wort,
$q =$ the required percentage of extract,
$p_1 =$ the percentage of extract of the adjunct,
$F =$ a constant factor $= 250$,
$G =$ the required amount of the adjunct in pounds.

The formula then is:

$$G = \frac{(F \times W) \times (q - p)}{p_1 - q}.$$

Example.—How many pounds of glucose of 80 per cent extract are required in order to raise the percentage of extract in 210 barrels of wort from 13.2 to 14.4?

Solution.—

$$W = 210,\ p = 13.2,\ q = 14.4,\ F = 250,\ p_1 = 80.$$

$$G = \frac{(250 \times 210) \times (14.4 - 13.2)}{80 - 14.4} = \frac{52500 \times 1.2}{65.6}.$$

$$= \frac{63000}{65.6} = 960.$$

Answer.—The required amount of glucose is 960 pounds.

YIELD CALCULATIONS ACCORDING TO M. SCHWARZ

CALCULATING YIELD FROM WORT IN FERMENTER.

Taking a wort of 13 per cent extract, which is the original *density for most* beers in the United States, whereby the specific

gravity becomes a constant factor, the following formula is deemed accurate enough for practical purposes:

Let W = barrels of wort in fermenters,
p = saccharometer reading of such wort.
B = total materials expressed in bushels of malt,
Y = the yield.

The formula then is:

$$Y = \frac{W \times p \times 8}{B}.$$

Example.—500 bushels of malt yield 288 barrels of wort in fermenters at 13.5 per cent Balling. What is the yield?

Solution.—

$$W = 288,\ p = 13.5,\ B = 500.$$

$$Y = \frac{288 \times 13.5 \times 8}{500} = \frac{31104}{500} = 62.2.$$

Answer.—The yield is 62.2 per cent.

CALCULATING YIELD FROM WORT IN KETTLE AFTER BOILING.

The amount of wort which leaves the kettle differs from that which reaches the fermenters, since in passing from the kettle to the fermenter the volume of the wort shrinks on an average 10 per cent, while the density increases by the evaporation of water, causing an increase of 4 per cent in extract. If it is desired to calculate the yield from the amount of wort in the kettle after boiling, the formula given for calculating the yield from the amount of wort in the fermenter can be used with this modification that the specific gravity factor 8 is changed to 7.5.

Let W = barrels of hot wort in the kettle,
p = Balling reading at 14° R.,
B = total materials calculated in bushels of malt,
Y = the required yield of extract.

The formula then is:

$$Y = \frac{W \times p \times 7.5}{B}.$$

Example.—Taking the example given for calculating yield from amount of wort in fermenter, as above, there is obtained the following:

Solution.—Taking into consideration the contraction of the volume of wort from kettle to fermenter, the amount of wort

[redacted]

of 13 per cent in the kettle, according to the above figures, is 320 barrels. Hence,

$$W = 320,\ p = 13,\ B = 500.$$

$$Y = \frac{320 \times 13 \times 7.5}{500} = \frac{31200}{500} = 62.4.$$

Answer.—The yield is 62.4 per cent.

MECHANICAL YIELD CALCULATOR BY J. E. SIEBEL.

A device for calculating the yield mechanically has been invented by J. E. Siebel, and is shown in the accompanying illustration. It is of a size to allow the printed matter on its dial to be read with ease, the illustration being considerably reduced in size.

The inside dial bearing the legend, "pounds of material," can be *turned around* the center, and the Vernier or segment of a

circle, showing on one division gravity of wort and on another yield in per cent, can also be turned around partially. The dial showing the number of barrels of beer, or rather wort, remains stationary. The dials comprise a range of material from 1,000 to 40,000 pounds, and from 20 to 800 barrels of wort. The gravities shown on this diagram include the degrees 7 to 16, and the yields from 45 to 88 per cents, but the range of these figures may be enlarged, if desirable, on the same principle. It will be observed that in using this device it is immaterial what kind of saccharometer is used to determine the gravity of the wort, as it gives the percentage of yield always in the same denomination corresponding to that of the saccharometer. Moreover, the instrument is equally applicable if different weights and measures are used to indicate quantities of wort and raw material if the zero or starting point on the margin is shifted to a position which can be readily determined. Thus in using the point XO a little to the right of the zero point, as such, the instrument gives correct indications of yield if German pounds are used for material and hectoliters for barrels. In other words, by shifting the zero point to a point readily ascertainable in any given case, the apparatus may be adapted to any system of measurement, number of gallons per barrel, etc.

HEAT CALCULATIONS ACCORDING TO M. HENIUS.

THE BREWER'S HEAT UNIT.

For practical purposes when making calculations in the brewery we do not employ the heat unit as given in the chapter on Physics. A heat unit, as understood for the purpose of practical figuring in the brewery, is the amount of heat required to raise the temperature of one barrel of water one degree Réaumur.

The heat required to raise the temperature of larger quantities of water of a given temperature is governed by the weight of the water and the number of degrees by which the temperature is to be raised, but is independent of the original temperature of the water. In other words, in order to raise one barrel of water from 0° R. to 10° R., an equal amount of heat (= 10 heat-units) is required as to raise one barrel of water from 15° R. to 25° R., the rise being 10° in each case, and each degree requiring one *heat-unit per* barrel of water. Likewise, in order to raise five *barrels of water* of 20° R. to 80° R., five times as much heat is

[redacted]

required as to raise one barrel water from 20° to 80°, viz., $5 \times 60 = 300$ heat-units.

To heat 1 bbl.	water from 0° R. to 1° R. or by 1°, requires	1 h. u.
To heat 1 bbl.	water from 0° R. to 10° R. or by 10°, requires	10 h. u.
To heat 1 bbl.	water from 35° R. to 50° R. or by 15°, requires	15 h. u.
To heat 2 bbls.	water from 35° R. to 50° R. or by 15°, requires	2x15=30 h. u.
To heat 50 bbls.	water from 15° R. to 80° R. or by 65°, requires	50x65=3250 h. u.

The amount of heat contained in a given quantity of water depends upon the weight of the water and its temperature. Thus, one barrel of water of 50° R. contains 50 heat-units, 20 barrels water of 50° contain $20 \times 50 = 1000$ heat-units.

Remark: The temperature of boiling water and boiling mash is taken at 78° R. in all subsequent calculations, since the water loses about 2° R. during its passage through the pipes.

CALCULATIONS WHERE WATER ONLY IS USED.

TO FIND TEMPERATURE OF MIXTURE OF WATER.

Example 1.—75 bbls. of water of 15° R. is mixed with 50 bbls. water of 70° R. What is the temperature of the mixture?

Solution.—

75 bbls. water of 15° contains $75 \times 15 = 1125$ heat-units.
50 bbls. water of 70° contains $50 \times 70 = 3500$ heat-units.

125 bbls. mixed water contains 4625 heat-units.

One barrel mixed water, then, contains the 125th part of the total heat of 4625 units.

$$4625 \div 125 = 37,$$

or 37 heat-units. Water possessing 37 heat-units per barrel has a temperature of 37°, hence:

Answer.—Temperature of the mixed water = 37° R.

TO FIND TEMPERATURE OF COLD WATER.

Example 2.—By mixing 20 barrels of boiling water with 12 barrels of cold water, the temperature of the mixture is 54° R. What was the temperature of the cold water?

Solution.—

12 bbls. water ? R.
20 bbls. water 78° R. contains $20 \times 78 = 1560$ heat-units.

32 bbls. mixed water of 54° contain $32 \times 54 = 1728$ heat-units.

From the total amount of heat of 1728 units, deduct the heat supplied by the boiling water = 1560 units. The remainder is the amount of heat that must be contained in the 12 bbls. cold water.

1728 heat-units = total amount of heat.
1560 heat-units = heat of boiling water.

168 heat-units = heat of cold water.

Dividing the amount of heat in the cold water by the number of barrels gives the temperature:

$$168 \div 12 = 14.$$

One barrel of cold water contains 14 heat-units, or

Answer.—Temperature of the cold water = 14° R.

TO FIND AMOUNT OF COLD WATER.

Example 3.—How many barrels of cold water of 15° R. are required in order to cool 30 barrels of water of 72° R. to 60° R.?

Solution.—In cooling the hot water from 72° to 60°, that is, by 12 degrees, each barrel of water gives up 12 heat-units, hence the 30 barrels of water give up 30 × 12 = 360 heat-units. This amount of heat serves to raise the temperature of the cold water from 15° to 60° to reach the final temperature of 60° in the mixed water. To raise the temperature as required from 15° to 60° = 45°, each barrel of cold water must receive an addition of 45 heat-units. There is a total of 360 heat-units available, which is given off by the hot water. It must be found how many barrels of cold water can be heated to 60° R., using 45 heat-units for each barrel.

One barrel cold water takes up 45 heat-units.
How many barrels cold water take up 360 heat-units?

$$360 \div 45 = 8 \text{ bbls.}$$

Answer.—8 barrels of cold water is required.

TO FIND AMOUNT OF BOILING WATER.

Example 4.—How many barrels of boiling water of 78° R. will be required to raise 20 barrels of water from 30° to 56°?

Solution 1.—To heat 20 barrels water from 30° to 56°, that is, by 26 degrees, requires 20 × 26 = 520 heat-units, which is taken from the boiling water. This water is thereby cooled from 78° to 56°, that is, by 22 degrees. Hence, each barrel of boiling water gives off 22 heat-units.

One barrel boiling water gives off 22 heat-units.
How many barrels boiling water give off 520 heat-units?

$$520 \div 22 = 23.6.$$

Answer.—It requires 23.6 bbls. of boiling water.

Solution 2 (Abridged).—Write the three temperatures in a column, beginning with the lowest and finishing with the highest. Take the difference between the first and the second temperatures, multiply it by the number of barrels, and divide the product by the difference between the second and third temperatures. The result is the required number of barrels of boiling water.

$$\text{20 bbls. water} \qquad \begin{array}{l} 30^\circ \\ 56^\circ \\ 78^\circ \end{array} \begin{array}{l} > 26 \\ > 22 \end{array}$$

$$\frac{26 \times 20}{22} = 23.6.$$

Answer.—23.6 barrels of boiling water.

TO FIND AMOUNTS OF COLD AND OF BOILING WATER.

Example 5.—How many barrels of cold water of 12° and how many barrels of boiling water are required to secure 35 barrels of 64°?

Solution (Abridged).—Write the three temperatures in a column as in Example 4, multiply the number of required barrels by the difference between the first and second temperatures, and divide by the difference between the first and third temperatures. This gives the barrels of hot water required. Deducting this number from the total amount of water gives the barrels of cold water.

$$\text{35 bbls. water} \qquad \begin{array}{l} 12^\circ \\ 64^\circ \\ 78^\circ \end{array} \begin{array}{l} > 52 \\ > 66 \end{array}$$

$$\frac{52 \times 35}{66} = 27.5.$$

35	bbls. total water of 64°.
27.5	bbls. boiling water of 78°.
7.5	bbls. cold water of 12°.

Answer.—It requires 27.5 barrels of boiling water and 7.5 barrels of cold water.

CALCULATIONS WHERE MALT OR RAW CEREAL AND WATER ARE USED.

Whenever malt or cereals are to be mixed with water and it is desired to determine the temperatures of such mixtures (mashes) or find the required temperature of either of these materials it must be borne in mind that it takes less heat to raise the temperature of malt or cereals than it does to heat water. Taking water as a unit it requires only 0.4 of the heat used in heating water to raise the temperature of an equal weight of malt an equal number of degrees. The figure 0.4 is called the specific heat of malt. (See "Physics.") For specific heat calculations in the brewery it is convenient to take 1,000 pounds of malt as a basis and to express its heat capacity in barrels of water.

One barrel of water weighs 258.5 pounds, but results sufficiently accurate may be obtained by taking the figure 250 as the weight of one barrel, or 1,000 pounds for four barrels. In short:

250 pounds malt = 1 barrel of water in weight.
or 1000 pounds malt = 4 barrels of water in weight.

Since the specific heat of malt is 0.4, we have

1000 pounds malt = 4 barrels $\times$ 0.4 = 1.6 barrel of water, as to heat capacity.

In order, then, to find the heat capacity of a given quantity of malt or cereals calculate 1.6 barrel of water for each 1,000 pounds of malt or cereals, or divide the number of pounds of malt or cereals by 1000 and multiply by 1.6.

Example 1.—5400 lbs. malt of 18° R. is doughed-in with 50 bbls. water of 33° R. What is the temperature of the mash?

Solution.—

$$5400 \div 1000 = 5.4.$$
$$5.4 \times 1.6 = 8.64.$$

5400 lbs. malt correspond to 8.6 bbls. water as to heat capacity.

8.6 bbls. water of 18° contain	$8.6 \times 18 =$	154.8 heat-units.
50 bbls. water of 33° contain	$50 \times 33 =$	1650 heat-units.
58.6 bbls. mash contain		1804.8 heat-units.

$$1804.8 \div 58.6 = 30.8.$$

Answer.—Temperature of mash = 30.8° R.

[redacted]

CALCULATIONS AT THE MASH TUB.

TO FIND THE TEMPERATURE OF THE DOUGHING-IN WATER.

Example.—6500 pounds of malt of 15° R. is doughed-in with 60 barrels of water. The temperature of the mash is to be 30° R. What should be the temperature of the doughing-in water?

Solution.—

$$6500 \div 1000 = 6.5.$$
$$6.5 \times 1.6 = 10.4.$$

6500 lbs. malt correspond to 10.4 bbls. water as to heat capacity.

10.4 bbls. water of 15° R. contains $10.4 \times 15 = 156$ heat-units.
60 bbls. water of ? R.

70.4 bbls. mash of 30° R. contain $70.4 \times 30 = 2112$ heat-units.

From the total heat-units of the mash deduct the amount of heat supplied by the malt, and the result will be the heat contained in the water.

70.4	bbls. mash contains	2112 heat-units.
10.4	bbls. water (malt) contains	156 heat-units.
60	bbls. doughing-in water contains	1956 heat-units

$$1956 \div 60 = 32.6.$$

Answer.—Temperature of doughing-in water = 32.6° R.

TO FIND THE FINAL TEMPERATURE (TEMPERATURE OF THE TOTAL MASH).

Example.—Doughed-in in the mash tub, 8750 lbs. malt with 80 bbls. water. Temperature of malt mash = 32°. Doughed-in in rice cooker, 6500 lbs. grits and 1900 lbs. malt, with 84 bbls. water. What is the temperature of the total mash, after the cereal mash has been run into the malt mash?

Solution.—First find how many bbls. mash are contained in the mash tub and how many in the rice cooker:

1. Malt mash.

$$8750 \div 1000 = 8.75.$$
$$8.75 \times 1.6 = 14.0.$$

14 bbls. water (malt).
80 bbls. water.

94 bbls. malt mash.

2. **Cereal mash.**

6500 lbs. grits.
1900 lbs. malt.

8400 lbs. materials.

8400 ÷ 1000 = 8.4.
8.4 × 1.6 = 13.44.

13.44 bbls. water (materials).
84. bbls. water.

97.4 bbls. cereal mash.

94 bbls. malt mash of 32° contains 94 × 32 =	**3008 h. u.**
97.4 bbls. cereal mash of 78° contains 97.4 × 78 =	**7597.2 h. u.**
191.4 bbls. total mash contains	**10605.2 h. u.**

10605.2 ÷ 191.4 = 55.4.

Answer.—Final temperature = 55.4° R.

TO FIND THE DOUGHING-IN TEMPERATURE (TEMPERATURE OF THE MALT MASH).

Example.—Doughed-in in the mash tub, 6800 lbs. malt with 62 bbls. water. In rice cooker 5200 lbs. grits and 1500 bbls. malt with 64 bbls. water. Final temperature, i. e., temperature of total mash to be 56°. What should be the temperature of the malt mash when the cereal mash is run in?

Solution.—First find the bbls. of malt mash and cereal mash, respectively.

1. Malt mash.

6800 ÷ 1000 = 6.8
6.8 × 1.6 = 10.88.

10.88 bbls. water (malt).
62 bbls. water.

72.9 bbls. malt mash.

2. Cereal Mash.

5200 lbs. grits.
1500 lbs. malt.

6700 lbs. materials.

6700 ÷ 1000 = 6.7.
6.7 × 1.6 = 10.72.

[redacted]

10.72 bbls. water (materials).
64 bbls. water.

74.7 bbls. cereal mash.

72.9 bbls. malt mash of ? degrees.
74.7 bbls. cereal mash of 78° contains $74.7 \times 78 = 5826.6$ h. u.

147.6 bbls. total mash of 56° contains $147.6 \times 56 = 8265.6$ h. u.

From the heat-units of the total mash deduct the heat-units of the cereal mash; leaves the heat-units contained in the malt mash.

8265.6 h. u. in total mash.
5826.6 h. u. in cereal mash.

2439.0 h. u. in malt mash.

$$2439.0 \div 72.9 = 33.4.$$

Answer.—Doughing-in temperature = 33.4° R.

TO FIND THE NUMBER OF BARRELS OF CEREAL MASH.

Example.—Doughed-in in mash tub 5400 lbs. malt with 54 bbls. water. Temperature of mash = 35° R. How many barrels of cereal mash of 78° R., or boiling water, are wanted in order to raise the malt mash to 58°?

$$5400 \div 1000 = 5.4.$$
$$5.4 \times 1.6 = 8.64.$$

8.64 bbls. water (malt).
54 bbls. water.

62.6 bbls. malt mash.

Proceed according to abridged solution of Example 4, "Calculation where water only is used":

62.6 bbls. mash.

$$\begin{array}{lc} 35^\circ & \\ & 23 \\ 58^\circ & \\ & 20 \\ 78^\circ & \end{array}$$

$$\frac{62.6 \times 23}{20} = 71.99.$$

Answer.—Required, 72 bbls. cereal mash.

TO FIND THE BARRELS OF THICK MASH.

Example.—Doughed-in in mash tub 10500 lbs. malt with 100 bbls. water. Temperature of mash = 30°. The mash is to be heated by a thick mash to 40°, by a second thick mash to 52°

and by a "lauter" mash to 60°. How many barrels are required of the first and second thick mashes and the lauter mash?

Solution.—

$$10500 \div 1000 = 10.5.$$
$$10.5 \times 1.6 = 16.8.$$

16.80 bbls. water (malt).
100 bbls. water.

116.8 bbls. malt mash.

Proceed as in Example 5, "Calculation when water only is used":

1. Thick mash.

116.8 bbls. malt mash.

$$\begin{array}{ll} 30^\circ & \\ & 10 \\ 40^\circ & \\ & 48 \\ 78^\circ & \end{array}$$

$$\frac{116.8 \times 10}{48} = 24.3.$$

To raise the mash to 40° R. requires 24.3 bbls. thick mash. The total mash then has a temperature of 40°.

2. Thick mash.

116.8 bbls. malt mash.

$$\begin{array}{ll} 40 & \\ & 12 \\ 52 & \\ & 38 \\ 78 & \end{array}$$

$$\frac{116.8 \times 12}{38} = 36.9.$$

To raise the mash to 52° requires 36.9 bbls. thick mash. Temperature of total mash = 52°.

3. "Lauter" mash.

116.8 bbls. mash.

$$\begin{array}{ll} 52 & \\ & 8 \\ 60 & \\ & 26 \\ 78 & \end{array}$$

$$\frac{116.8 \times 8}{26} = 35.9.$$

To raise the mash to 60° requires 35.9 bbls. lauter mash.

Answer.—

First thick mash = 24.3 bbls.
Second thick mash = 36.9 bbls.
"Lauter" mash = 35.9 bbls.

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CALCULATIONS BY MEANS OF LATENT HEAT, ACCORDING TO M. HENIUS.

COOLING CAPACITY OF ICE.

If heat is applied to ice of 0° R. it melts and changes into ice-water. Though a large amount of heat is expended in melting the ice no rise in temperature is indicated by the thermometer as long as any ice is present. The heat so absorbed is called *latent heat.* It has been found that the amount of heat it takes to melt one pound of ice will raise the temperature of one pound of water from 0° R. to 63° R., or is equal to 63 heat-units. The cooling capacity of ice is, therefore, 63 heat-units. We may here also, as in the calculations with specific heat, take for our practical figuring one barrel of water (250 pounds) as the unit of weight, and a heat-unit will then be the amount of heat it takes to raise the temperature of one barrel of water one degree Réaumur.

MIXING ICE AND WATER.

To illustrate the difference between ice and ice-water as to cooling capacity, the following examples will suffice:

Example 1.—Ten barrels of water of 78° R. are to be mixed with 10 barrels of water of 0° R. What is the temperature of the mixture?

Solution.—

10 barrels of water of 78°	contain 10×78 h. u. =	780 h. u.
10 barrels of water of 0°	contain 10×0 h. u. =	0 h. u.
20 barrels of water contain		780 h. u.

or one barrel contains 780 heat-units $\div$ 20 = 39 heat-units, hence:

Answer.—Temperature of the mixture is 39° R.

Example 2.—Ten barrels of water of 78° R. are to be mixed with 10 barrels of ice (250 pounds each) of 0° R. What is the temperature of the mixture?

Solution.—The 10 barrels of water contain 78×10 heat units = 780 heat units. The 10 barrels of ice absorb 10×63 heat units = 630 heat units and are then changed into 10 barrels of ice water of 0° R. The heat units so absorbed are taken from the 780 heat units of the hot water, and after melting all the ice there *are left* 780 — 630 = 150 heat units in the hot wate

10 barrels of water containing 150 heat units
10 barrels of water containing 0 heat units

20 barrels of water containing 150 heat units.

One barrel contains $150 \div 20 = 7.5$ heat units.

Answer.—Temperature of the mixture is 7.5° R.

We see from the two examples that while 10 barrels of ice-water of 0° R. cools the water of 78° R. to 39° R. only, the same quantity of ice reduced the temperature to 7.5° R.

COOLING WATER BY ICE.

If ice is melted and the resulting ice-water of 0° R. is raised to a higher temperature, then the heat absorbed is the sum of the latent heat and the heat required to raise the temperature to the desired point.

Example 3.—We want to cool 10 barrels of water of 78° R. to 4° R. with ice. How many barrels of ice does it require?

Solution.—To cool 10 barrels from 78° R. to 4° takes $(78 - 4) \times 10$ heat units $= 740$ heat units, which must be absorbed by the ice. Each barrel of ice, when melting, absorbs 63 heat units, and as the water should have a temperature of 4° R., the melted ice must absorb four more heat units in rising from 0° to 4° R., or in all $63 + 4 = 67$ heat units. As 740 heat units must be absorbed it takes $740 \div 67 = 11$ barrels ice to cool 10 barrels of water from 78° R. to 4° R.

Answer.—It requires 11 barrels of ice (250 pounds each).

From the data given above we may construct the following formula:

$$\left.\begin{array}{c}\text{Bbls. ice required}\\ \text{(250 lbs. each)}\end{array}\right\} = \frac{\text{No. bbls. water} \times (\text{high temp.} - \text{end temp.})}{\text{Cooling capacity of ice} + \text{end temperature}}$$

It being more practical to get the result in tons of ice (2,000 pounds) instead of barrels of ice, 1 ton = 8 barrels, we can, by multiplying the barrels of ice, the latent heat and the end temperature by 8, change the formula as follows:

$$\text{Tons of ice} = \frac{\text{Barrels of water} \times (\text{high temp.} - \text{end temp.})}{\text{Cooling capacity} \times 8 + (\text{end temp.} \times 8)},$$

or taking latent heat $63 \times 8 = 504$ as 500 and abbreviating still further we have

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$$\text{Tons of ice} = \frac{\text{Barrels of water} \times (\text{high temp.} - \text{end temp.})}{500 + (8 \times \text{end temperature})}.$$

Example 4.—(Abridged Method.) Taking Example 3 as an illustration, we have:

Solution.—

Barrels = 10.
High temperature = 78° R.
End temperature = 4° R.

$$\text{Tons of ice} = \frac{10 \times (78 - 4)}{500 + (8 \times 4)} = \frac{10 \times 74}{500 + 32} = \frac{740}{532} = 1.39$$

Answer.—1.39 tons.

We found in Example 3 that we required 11 barrels of ice; as 8 barrels of ice = 1 ton of ice, we have 11 ÷ 8 = 1.38 tons, and in Example 4, using the formula, 1.39 tons, which proves that our formula answers all practical purposes.

COOLING WORT BY ICE.

If we have to cool wort by means of ice we may employ the formula for water without any changes, because the heat capacity of a barrel of wort is about the same as that of a barrel of water, as the following reflection will show: One barrel of ordinary cold wort of, say, 13 per cent Balling weighs 259 + 13 = 272 pounds and contains 35 pounds extract and 272 — 35 = 237 pounds of water. The 35 pounds of extract have a specific heat of 0.4 or a heat capacity of only 0.4 × 35 = 14 pounds of water. The heat capacity of a barrel of wort of 13 per cent Balling is, therefore, equal to 237 + 14 = 251 pounds of water.

Example 5.—131 barrels of wort is to be cooled by ice from 7° R. to 3° R.

Solution.—

Barrels = 131.
High temperature = 7° R.
End temperature = 3° R.

$$\text{Tons of ice} = \frac{131 \times (7 - 3)}{500 + (8 \times 3)} = \frac{131 \times 4}{500 + 24} = \frac{524}{524} = 1.$$

Answer.—We use 1 ton of ice to cool 131 barrels of wort from 7° R. to 3° R.

When figuring with hot wort, a barrel of which weighs les

than a barrel of cold wort, the formula gives results sufficiently accurate for all practical purposes.

In all the calculations no account has been taken of the ice melted by outside heat.

LATENT HEAT OF STEAM.

If a pound of steam of 80° R. is forced into water of 0° R. and condensed, the heat thus given out will raise the temperature of 5.37 pounds of water from 0° R. to 80° R., which is equal to $80 \times 5.37 = 430$ heat units. This amount of heat will also be absorbed in changing one pound of water of 80° (just on the verge of boiling) into one pound of steam of the same temperature or 80°. This heat is called the latent heat of vaporization, and is very nearly seven times the amount of heat absorbed by melting ice. The latent heat of steam at different pressures varies from that of steam of 80° R., but the differences being slight are not considered in the following.

The calculations for heating water with steam are very similar to those for melting ice, as a few examples will show.

Example 1.—How many pounds of steam are needed to heat 10 barrels of water from 14° R. to 40° R.

Solution.—Ten barrels of water equal 10×250 or 2,500 pounds of water, which, when warmed from 14° R. to 40°, or 26° R., require $2{,}500 \times 26$, or 65,000 heat units. One pound of steam gives off in the form of latent heat, 430 heat units, and the water so formed when cooling from 80° R. to 40° R., the desired temperature, an additional 40 heat units or a total of $430 + 40 = 470$ heat units. As the water needs 65,000 heat units and each pound of steam supplies 470 heat units we require $65{,}000 \div 470 = 138.5$ pounds steam.

Answer.—138.5 pounds of steam.

The formula, then, for figuring the number of pounds of steam it requires to heat a certain number of barrels of water would be

$$\text{Lbs. of steam} = \frac{\text{Bbls. water} \times 250 \times (\text{end temp.} - \text{low temp.})}{\text{Latent heat of steam } (430) + 80 - \text{end temp.}}$$

$$= \frac{\text{Barrels} \times 250 \times (\text{end temp.} - \text{low temp.})}{510 - \text{end temp.}}.$$

Example 2.—How many pounds of steam does it take to heat 120 barrels of water from 10° R. to boiling, 80° R.?

Solution.—

Barrels = 120.
End temperature = 80° R.
Low temperature = 10° R.

$$\text{Lbs. steam} = \frac{120 \times 250 \times (80 - 10)}{510 - 80} = \frac{30000 \times 70}{430} = 4884.$$

Answer.—4884 pounds of steam.

If we take the power of evaporation of 1 pound of coal to be 8 pounds of water, it would take $\frac{4884}{8} = 610$ pounds of coal to heat 120 barrels of water from 10° R. to boiling.

CALCULATION OF ATTENUATION.

In the calculation of attenuation Balling's treatise on attenuation (attenuate = thinning, decreasing the amount of extract) was used as a basis, but in a modified and simplified form, so as to meet the requirements of the practical brewer, for whose purpose the results obtained, which, to some extent, differ from those obtained by an exact chemical analysis, are sufficiently accurate.

BALLING OF WORT AND APPARENT EXTRACT.

In a wort the saccharometer (see "Saccharometry") indicates the number of pounds of extract contained in 100 pounds of wort, the Balling of wort. After adding yeast to this wort fermentation sets in (sugar is split up into alcohol and carbonic acid gas) and the saccharometer indication decreases day by day until the fermentation comes to a stop. The indications of the instrument, however, no longer, as they did in the wort originally, correspond to the extract *really* contained in the fluid because the beer contains alcohol which, being specifically lighter than water, allows the saccharometer to sink lower than it would do in a fluid containing an equal amount of extract dissolved in water only instead of in a mixture of water and alcohol. In other words, the saccharometer apparently indicates the extract contained in the beer while in reality it shows less than is actually present. The saccharometer indication of a beer is, therefore, *called apparent* extract.

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In the following the apparent extract will be designated as the "Balling of beer," which is identical with "saccharometer indication of beer," or "density of beer," while the "original density," "original gravity," "original wort," or "extract of wort" will be designated as "Balling of wort," which then means the number of pounds of extract contained in one hundred pounds of wort in the cellar.

REAL EXTRACT.

In order to find the actual amount of extract contained in beer by means of a saccharometer it is necessary for reasons given above to remove the alcohol by distillation, and then add water again until the original weight is restored. In the liquid so obtained, free from alcohol, the saccharometer will show the extract contained in the beer. This is called the "real extract."

If we know the extract contained in the original wort, "Balling of wort," and the extract (sugar) fermented, we can readily ascertain the extract of the beer by deducting the extract fermented from the "Balling of wort."

APPARENT ATTENUATION AND REAL ATTENUATION.

The difference between the Balling of wort and the Balling of beer is called the "apparent" attenuation. It is the decrease of the saccharometer indication during fermentation.

The difference between the Balling of wort at the time when fermentation began, and the extract in the beer, is called the "real" attenuation, because it shows the actual decrease of extract by fermentation and represents the amount of sugar that has been fermented.

CALCULATING ALCOHOL CONTENT.

Since the real attenuation represents approximately the fermented sugar, it serves as a basis from which to figure the amount of alcohol in the beer, the effect of fermentation being to split up the sugar into two almost equal parts, one of alcohol, the other of carbonic acid. The latter escapes almost wholly, whereas the alcohol remains in the beer. The amount of alcohol can be found, therefore, by dividing the real attenuation by two.

The alcohol can also be calculated from the apparent attenuation by multiplying the same by a given alcohol factor, which differs according to the original density of the wort. For an original density of 11 per cent Balling the alcohol factor is 0.417; for a

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wort of 14 per cent it is 0.423, average 0.42. Now, the Balling indication of nearly all worts lies between the figures given. For practical purposes sufficient accuracy is, therefore, obtained by using 0.42 as the alcohol factor.

The alcohol content of beer, accordingly, can be calculated in either of two ways:

1. by dividing the real attenuation by 2, or
2. by multiplying the apparent attenuation by 0.42.

And, vice versa, the two attenuations can be found from the alcohol content, that is,

1. the real attenuation by multiplying the alcohol content by 2, and
2. the apparent attenuation by dividing the alcohol content by 0.42.

ATTENUATION FORMULA.

Summarizing we have:

Saccharometer indication	= Balling	= B.
Original wort extract	= Balling of wort	= B. W.
Apparent extract	= Balling of beer	= B. B.
Balling of wort — Balling of beer	= Apparent attenuation	= A. A.
Apparent attenuation $\times$ 0.42	= Alcohol	= Al.
Alcohol $\times$ 2	= Real attenuation	= R. A.
Balling of wort — real attenuation	= Real extract in beer	= R. E.

Example 1.—A wort in the cellar weighs 13 B. After fermentation the saccharometer indicates 4 B. How much alcohol and extract does the beer contain? What is the real and what the apparent attenuation?

Solution.—

Balling of wort............... = 13
Balling of beer............... = 4

Apparent attenuation .... = 9
$\times$ 0.42

Alcohol .... = 3.78
$\times$ 2

Real attenuation .... = 7.56

Balling of wort............... = 13
Real attenuation .... — 7.56

Real extract .... = 5.44

Answer.—The beer contains 3.78 per cent alcohol and 5.44 per cent extract. The real attenuation is 7.56, the apparent attenuation, 9.

APPARENT AND REAL DEGREE OF ATTENUATION.

In comparing two beers as to their apparent or real attenuation it is obvious that satisfactory results cannot be obtained if we do not know the *percentage* of the *extract*, which apparently or really attenuated, and this we can only figure out if the Balling of wort is known.

The following will serve as an illustration:

The analyses of two beers gave these results:

	No. 1.	No. 2.
Balling of wort	13.5	15.00
Balling of beer	3.5	5.00
Apparent attenuation	10.00	10.00
Alcohol	4.2	4.2
Real attenuation	8.4	8.4
Real extract of beer	5.1	6.6

It will readily be seen from the above figures that if we were to judge the two beers as to their composition, and only knew either the apparent or the real attenuation, or both, we would be justified in calling these beers identical. That they, however, are different we learn by noting the Balling of wort, which is different in the two beers, but still we cannot form an opinion as to their attenuation (real or apparent) before we have found the percentage of the extract that really or apparently fermented. This can easily be calculated by dividing the real or apparent attenuation by the Balling of wort, and multiplying by 100. We thus convert the apparent, or real attenuation into per cent of apparently or really fermented extract, and the figures so obtained we may, for purposes of convenience, which will be readily understood, term "apparent degree of attenuation" and "real degree of attenuation."

The apparent degree of attenuation then shows how many out of a hundred parts of extract *apparently* fermented, the real degree of attenuation, how many parts out of one hundred parts *really* fermented.

$$\frac{\text{Apparent attenuation} \times 100}{\textit{Balling}\text{ of wort}} = \text{Apparent deg. of atten.} = \text{A. D. A.}$$

$$\frac{\text{Real attenuation} \times 100}{\text{Balling of wort}} = \text{Real degree of attenuation} = \text{R. D. A.}$$

Example.—Balling of wort is 14. Balling of beer from this wort is 4.5. What is the apparent degree of fermentation and what the real degree of fermentation?

Solution.—

B. W. (Balling of wort).............. 14
B. B. (Balling of beer).............. 4.5
A. A. (apparent attenuation)........ 9.5
Al. (alcohol)...............$9.5 \times 0.42 = 4$
R. A. (real attenuation)........$4 \times 2 = 8$
R. E. (extract in beer)........$14 - 8 = 6$

$$\text{A. D. A.} = \frac{\text{A. A.} \times 100}{\text{B. W.}} = \frac{9.5 \times 100}{14} = 67.8.$$

$$\text{R. D. A.} = \frac{\text{R. A.} \times 100}{\text{B. W.}} = \frac{8 \times 100}{14} = 57.1.$$

Answer.—Apparent degree of attenuation = 67.8. Real degree of attenuation = 57.1.

SUGAR DEGREE.

The extract of wort consists of a number of substances, chief of which are sugars, then follow dextrins, malto-dextrins, albuminoids, mineral substances, hop extract, lactic acid, etc. It has been customary heretofore to express the relative amount of sugar in the extract in the form of ratio of sugar to the other substances (non-sugar), taking either 100 or 1 as the sugar basis, but as the figures so obtained are misleading, especially if 100 is taken as a unit, and consequently the percentage of sugar and the ratio of sugar are often confounded, we have adopted, in conformity with the terms real and apparent degree of attenuation, the term "sugar degree," which simply means the parts of reducing sugars (commonly called sugar) contained in 100 parts of extract.

$$\text{S. D. (sugar degree)} = \frac{\text{Sugar} \times 100}{\text{B. W.}}.$$

Example.—By analysis it was found that a wort contained 13 per cent of extract, 9 parts of which were reducing sugars. *What is the sugar degree?*

Solution.—In 13 parts of extract, 9 are sugar, how many parts in 100 will be sugar?

$$\frac{9 \times 100}{13} = \frac{900}{13} = 69.2.$$

Answer.—Sugar degree is 69.2.

RATIO OF SUGAR TO NON-SUGAR.

If it is desired to find the ratio of sugar to non-sugar proceed in the following manner:

Example.—In 13 parts of extract, 9 parts were sugar, consequently 13 — 9 = 4 parts were non-sugar.

Solution.—

$$\underset{\text{Sugar}}{9} : \underset{\text{Non-sugar}}{4} = \underset{\text{Sugar}}{100} : \underset{\text{Non-sugar.}}{?}$$

$$\frac{4 \times 100}{9} = \text{Non-sugar.}$$

$$44 = \text{Non-sugar.}$$

Answer.—Ratio of sugar to non-sugar 100 : 44, or, if the sugar unit is one, 1 : 0.44.

FIGURING IN ENGLISH BREWERIES.

One barrel (English) = 36 gal., 10 lbs. each = 360 lbs.
A quarter (English) = 8 bu., 42 lbs. each = 336 lbs.
A hundredweight (cwt.) = 112 lbs.
L = saccharometer indication according to Long's scale (see below).

GRAVITY.

By "Gravity" the English brewer understands either "Brewers' Pounds" or "Degree of Specific Gravity."

BREWERS' POUNDS AND LONG'S SCALE.

"Brewers' Pounds" expresses the number of pounds a barrel of wort weighs more than a barrel of water of 360 pounds at 60° F. If a barrel of wort weighs 375 pounds the wort will then be called a 15-pound wort (375 — 360 = 15). After fermentation, this beer would still be called a 15-pound beer. Long's saccharometer, which is in general use, indicates "Brewers' Pounds."

DEGREE OF SPECIFIC GRAVITY.

If we take 1,000 parts of water as a unit of weight and weigh *an equal volume* of wort (or beer) at the same temperature, then

the relation between the weight so obtained and 1,000 gives us the specific gravity of the wort or beer.

It is not customary, however, to give the specific gravity of the wort or beer, but simply to use the figure in excess of 1,000 which is called the "degree of specific gravity."

Example.—If the specific gravity of a wort is 1,050, then we speak of the wort as a 50 gravity wort (1,050 — 1,000 = 50), or the degree of specific gravity of the wort is 50.

TO CONVERT DEGREES OF SPECIFIC GRAVITY INTO BREWERS' POUNDS.

From the above it will be readily seen that 1,000 holds the same relation to "degree of specific gravity" as 360 to "brewers' pounds" (or Long).

$$\frac{\text{Brewers' lbs.}}{\text{D. S. G.}} = \frac{360}{1{,}000} = \frac{0.36}{1} = 0.36.$$

Therefore, by multiplying the degrees of specific gravity by 0.36 we obtain the equivalent in brewers' pounds.

Example.—Degree of specific gravity of a wort is 60. State equivalent in brewers' pounds.

Solution.—

$$60 \times 0.36 = 21.6.$$

Answer.—Brewers' pounds = 21.6.

TO CONVERT BREWERS' POUNDS INTO DEGREES OF SPECIFIC GRAVITY.

By dividing the brewers' pounds by 0.36 we obtain the degree of specific gravity.

Example.—How many degrees specific gravity are 15 brewers' pounds?

Solution.—

$$\frac{15}{0.36} = 41.67.$$

Answer.—41.67 degrees specific gravity.

We may also multiply by 2.78 ($1 \div 0.36 = 2.78$). Taking above example we have $15 \times 2.78 = 41.7$.

SOLID EXTRACT PER BARREL.

The brewers' pounds per barrel shows us the excess weight of a barrel of wort as compared to a barrel of water, but gives us no

information about the actual quantity of solid extract contained in a barrel of wort. In order to understand the relation between the brewers' pounds and the actual pounds of solid extract contained in a barrel of wort the following will serve as an illustration:

One barrel of water weighs 360 pounds. If we mix 35 gallons of water with one gallon of dry sugar, a gallon of water weighing 10 pounds and a gallon of sugar weighing 16 pounds we have

35 gals. of water, 10 lbs. each, weighs 350 lbs.
1 gal. of sugar, 16 lbs. each, weighs 16 lbs.

36 gallons of water and sugar weighs 366 lbs.

Brewers' pounds of this wort are 6 ($366 - 360 = 6$), while the barrel contains 16 pounds of solid extract; therefore, the ratio between the solids contained in the wort and the brewers' pounds is 16 to 6 or about 2.67. (The correct figure is 2.59, but 2.6 is generally employed.) This calculation is based upon the fact that cane sugar has the same sp. gr. as dry malt extract. As 1 brewers' pound = 2.6 pounds sugar (or extract) 1 pound of sugar = $\frac{1}{2.6}$ or 0.39 brewers' pounds, and a cwt. of sugar = 112×0.39 or 43.68 brewers' pounds, or 1 cwt. of dry cane sugar will yield 43 brewers' pounds. A glucose, although apparently dry, may have several per cent water and will consequently yield less than 43.

TO CONVERT BREWERS' POUNDS INTO SOLID EXTRACT PER BARREL.

Rule.—Multiply brewers' pounds by 2.6.

Example.—Brewers' pounds of a beer = 25; how many pounds of solid extract does the barrel contain?

Solution.—

$$25 \times 2.6 = 65.$$

Answer.—A barrel contains 65 pounds of solid extract.

TO CONVERT POUNDS OF SOLID EXTRACT INTO BALLING.

By multiplying brewers' pounds by 2.6 we find, as shown above, the number of pounds of solid extract contained in a barrel of wort. Knowing now the weight of a barrel of wort ($360 + L$) and the solid extract contained therein ($L \times 2.6$) we can readily ascertain the pounds of solid extract contained in 100 parts of the wort, or the Balling indication, as follows:

$$B = \frac{L \times 2.6 \times 100}{360 + L.} = \frac{260 \times L.}{360 + L.}.$$

Example.—What is the Balling of a 25 pound wort?

Solution.—

$$\frac{260 \times 25}{360 + 25} = \frac{6500}{385} = 16.9.$$

Answer.—16.9 Balling.

YIELD.

In England it is customary to express the yield in pounds extract per quarter of malt, which, of course, is entirely arbitrary and has nothing in common with the yield proper that expresses the number of pounds of solid extract obtained from 100 pounds of material. By multiplying the number of barrels of wort obtained in a brew by the gravity (Long) and dividing by the number of quarters used, we obtain the extract yielded per quarter of malt. If sugar is used the extract obtained from the sugar must first be deducted before division takes place.

$$\text{Brewers' extract yielded} = \frac{\text{barrels} \times \text{brewers' lbs. (Long)}}{\text{Number of quarters}}.$$

$$= \frac{\text{Bbls.} \times \text{L.}}{\text{Qrs.}}.$$

Rule.—Multiply number of barrels by brewers' pounds (Long) and divide by number of quarters.

Example 1.—100 barrels brewed at 20 pounds employing 23.5 quarters of malt; state the yield.

Solution.—

$$\frac{100 \times 20}{23.5} = 85.$$

Answer.—Yield per quarter 85.

Example 2.—300 barrels wort were brewed at 20 pounds from 57 quarters of malt and 30 cwt. of sugar (sugar yielding 35 extract per cwt.). State the yield.

Solution.—

$$\frac{(300 \times 20) - (30 \times 35)}{57} = \frac{6000 - 1050}{57} = 87.$$

Answer.—87 yield extract per quarter.

SOLID EXTRACT PER QUARTER.

The solid extract of a quarter can readily be found by multiplying the extract per quarter by 2.6 (this factor is approximately correct).

Rule.—Multiply extract per quarter by 2.6.

Example.—Brewers' extract per quarter = 87; how many pounds of solid extract does a quarter yield?

Solution.—

$$87 \times 2.6 = 226.2.$$

Answer.—One quarter yields 226.2 pounds of solid extract.

SOLID EXTRACT PER HUNDRED POUNDS, OR EXTRACT PER CENT.

Knowing the solid extract per quarter (336 pounds) we can readily find the solid extract obtained from 100 pounds (extract per cent) of malt by multiplying by 100 and dividing by 336, or dividing by 3.36 ($\frac{336}{100}$).

Rule.—Divide solid extract per quarter by 3.36.

Example.—Solid extract per quarter = 226.2; what is the extract per cent?

Solution.—

$$\frac{226.2}{3.36} = 67.3.$$

Answer.—Extract per cent = 67.3.

TO CONVERT BREWERS' EXTRACT PER QUARTER INTO EXTRACT PER CENT YIELDED.

By employing the two preceding rules we derive the following rule:

$$\text{Extract per cent} = \frac{\text{Lbs. per quarter} \times 2.6}{3.36}.$$

$$= \text{Lbs. per quarter} \times \frac{2.6}{3.36}.$$

$$= \text{Lbs. per quarter} \times 0.774$$

Rule.—Multiply pounds per quarter by 0.774.

Example.—Pounds per quarter 83.5. Find extract per cent.

Solution.—

$$83.5 \times 0.774 = 64.6.$$

Answer.—64.6 per cent extract.

TO FIND QUANTITIES OF MATERIALS TO BE USED.

The quantity of material to be used in a brew can be found *multiplying* the number of barrels to be brewed by the desired

[redacted]

gravity (pounds) and dividing by the extract yielded per quarter. If materials other than malt are to be employed the extract yielded by them should be deducted from the extract yielded by the malt before dividing by the extract per quarter of malt.

$$\text{Quarters} = \frac{\text{Barrels} \times \text{brewers' pounds (L.)}}{\text{Extract per quarter}}.$$

Example 1.—In producing 200 barrels of 18 pounds a malt is employed yielding 86 pounds extract per quarter. How many quarters of malt are required for the brew?

Solution.—

$$\frac{200 \times 18}{86} = 41.9.$$

Answer.—We employ 41.9 quarters of malt.

Example 2.—The same number of barrels of same strength as in Example 1 are to be brewed from malt and sugar, using 20 cwt. of glucose (yielding 36 pounds per cwt.). How much malt is required?

Solution.—

$$\frac{(200 \times 18) - (20 \times 36)}{86} = \frac{3600 - 720}{86} = 33.5$$

Answer.—We employ 33.5 quarters of malt.

SUMMARY.

In figuring according to English usage it should then be borne in mind that:

1. Brewers' pounds = excess of weight, in pounds, of a barrel of wort (or beer) over a barrel of water (360 pounds).
2. Pound beer or pound gravity or saccharometer indication according to Long = L. = brewers' pounds (see 1).
3. Specific gravity or degree of specific gravity = excess number over 1,000 (the unit of water).
4. Extract, or brewers' extract, per quarter, generally 80—90 pounds, is an arbitrary figure based upon the extract as indicated by the Long saccharometer.
5. Dry or solid extract = real extract contained in wort or beer.
6. Extract per cent = solid extract per 100 pounds of material.
7. Material = quarters of malt.
8. *Final attenuation* of a beer is the saccharometer indicatio[illegible] *of the beer* according to Long.

THE BREWER'S CHEMICAL LABORATORY.

In this chapter are given such analytical methods as are used most commonly in the examinations required to be made in the practice of brewing, when it is desired to examine materials employed, or the product in its various stages, in testing instruments and appliances, or determining the properties of the finished article. Examinations of this character are necessarily confined to what the brewer, in the course of his regular occupation, can attend to, and it is not purposed to go into the more thorough and detailed analytical methods, which are employed in the scientific laboratories.

The object is to aid and refresh the memory of a brewer who has taken a course in scientific brewing, but may not be able, where his mind is taken up in the work of operative brewing, to remember the details of every method and, therefore, will be grateful for a handy reference book to which he can turn and quickly find the necessary information.

Originality is not claimed for all the methods here given. The effort has been to select those which combine in the highest practical degree the two qualities most needed for the work in the laboratory, viz., reliability and dispatch. Some of the methods differ little from those given in the standard treatises. The methods for analyzing beer, wort, malt and barley, are practically identical with those in vogue in Europe, and those for water have also been in common use for a long time. Of the rest, many can be classed as distinctly American, having been evolved under the requirements peculiar to the brewing industry of the United States. They are, in a large measure, the result of patient, careful, and in part, at least, original work on the part of the scientific station of Wahl and Henius of Chicago, devised with a view to supplying the needs of the American brewer.

In regard to brewing materials, this chapter will supplement

that devoted entirely to that subject, as far as methods of examination are concerned.

To make the descriptions more complete, mention is made of the apparatus and chemicals required to equip a chemical laboratory sufficient for a brewer to do his work, and the tests given by which the fitness and accuracy of the appliances may be determined.

ANALYTICAL CHEMISTRY.

Analytical chemistry treats on the determination of the elements of a compound, the proportion of the constituents and the presence of impurities.

If we merely take into consideration the kind of their constituents the analysis is a *qualitative* one, as testing for starch in wort and beer; iron in water, lupulin and sugars; tannic acid in lupulin.

If, however, the amount of each constituent is determined, then the analysis is a *quantitative* one.

Volumetric analysis is the analysis by measure.

Gravimetric analysis is the analysis by weight.

SPECIFIC GRAVITY.

To Find the Specific Gravity of Solid Bodies.—The simplest method of finding the specific gravity of solid bodies is based on the principle of Archimedes. According to this principle, a solid body immersed in water apparently loses weight, and this apparent loss is equal to the weight of the water which it displaces, or to its own volume of water.

To determine the specific gravity of a solid body, such body is first weighed in air, next suspended from the balance pan by a fine thread or horsehair and immersed completely in pure water of 60° F. and again weighed while immersed. It now weighs less, the difference being the weight of the displaced water.

Dividing the weight of the body in air by the weight of an equal volume of water we obtain the specific gravity of the body compared to water of 60° F.

Example.—A stone weighs in air...................... 108 lbs.
When suspended in water the same stone weighs .... 70 "

Difference, being the weight of an equal volume of water, *38 lbs., and* $108 \div 38 = 2.84$, the specific gravity of the stone.

To Find the Specific Gravity of Gases.—Gases are compared to air as standard. The specific gravity of a gas is found in the same way as that of a solid, that is, by weighing equal volumes of the gas and air, and dividing the weight of the gas by the weight of the air.

Example.—One cubic foot of carbonic acid gas weighs....1.976 oz.
One cubic foot of air weighs ....1.3 "
$1.976 \div 1.3 = 1.52$; hence the specific gravity of carbonic acid gas is 1.52, that is, carbonic acid gas is 1.52 times as heavy as air.

To find the specific gravity of liquid with an ordinary flask.—Weigh a flask, first, empty; next, full of water; then, full of the given liquid. Subtract the weight of the empty flask from each of the other two weights; the remainders represent the weights of equal volumes of water and the other liquid. Divide the weight of the liquid by the weight of the water, and the quotient is the specific gravity of the liquid.

Example.—A flask filled with water weighs.........55.9 oz.
Same flask filled with wort weighs........58.2 oz.
Empty flask weighs ....24.1 oz.

Subtracting 24.1 oz. from 55.9 oz. gives weight of water 31.8 oz.
Subtracting 24.1 oz. from 58.2 oz. gives weight of wort 34.1 oz.
Divide 34.1 oz. by 31.8 oz., and the quotient of 1.07 indicates that the wort is 1.07 times as heavy as an equal volume of water, or, that the specific gravity of the wort is 1.07.

Another and simpler way of finding the specific gravity of a liquid is to let a body lighter than the liquid float in it. The denser the liquid is, the less deep does the floating body sink into it.

Water at 15° C. has been accepted in the brewer's laboratory as a convenient standard of specific gravity for worts, beers and other liquids, the specific gravities of which vary with the amounts of alcohol, sugar or other substances held by them in solution.

The picnometer is the only strictly reliable instrument for the determination of the specific gravity of a liquid, from which the quantity of sugars and other solids, or of alcohol, present in a *wort or* beer, can be found by referring to proper tables.

Balling's extract tables give, in convenient columns, the amounts *of extract* corresponding to specific gravities. After the latter has

been obtained by the instrument, the corresponding weight per cent of extract will be found in the table.

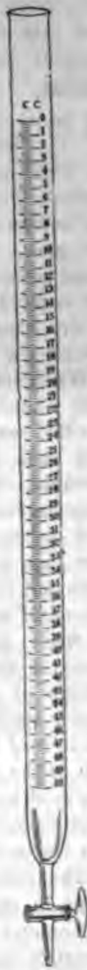
Alcohol tables give the weight per cent of alcohol in beer for a certain specific gravity of an alcoholic solution.

THE PICNOMETER.

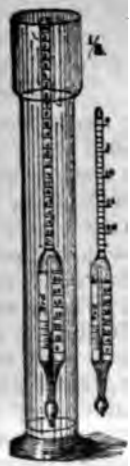
This instrument should hold very nearly (within a decigram) 50 grams of distilled water at 15° C. Before using, the picnometer should be dried completely, which can be most easily effected by rinsing with 96 per cent alcohol, which, in turn, is removed by air from the bellows. The instrument is then accurately weighed, together with its capillary stopper. A quart pail, or dish, is filled with hydrant water, and some pieces of ice are added to hasten the cooling. The picnometer is filled with distilled water and immersed in the pail. A clean, dry, thin and accurate centigrade thermometer is used to indicate the temperature in the picnometer, and as a stirring rod. When the distilled water has a uniform temperature of 15° C., the picnometer is drawn from the pail, filled to the brim with distilled water and closed with the stopper containing the capillary tube, care being taken to avoid bubbles between stopper and liquid. The top of the plug is dried with a soft, clean, dry towel, and the whole instrument immersed so as to be almost covered by the cooling bath. The cooling liquid should not show more than 4 or 5° C., and in a warm room the cooling must be continued longer than in a cold room, so that the liquid in the picnometer may not expand and escape from the capillary stopper, while weighing the instrument. The plunging of the picnometer in the cold water causes the glass to contract, and a small drop of water is forced out at the top of the stopper; it sinks back again, however, as soon as the water in the picnometer begins to cool below 15° C. When the water has contracted to the bottom of the capillary tube of the stopper, draw the instrument from the cold water, dry it carefully with a soft, clean, dry towel, and weigh to milligrams. From this weight of the full picnometer, deduct the weight, previously obtained, of the empty picnometer. The difference will be the weight of the distilled water contained in the picnometer.

After finding the weight of the picnometer and the weight of the water it can hold at 15° C., we ascertain the weight of a wort, beer, or alcohol solution, in precisely the same manner as that of distilled water, the same precautions being observed. Suppose

Thermometer.



Burette.



Saccharometer and Cylinder.

[redacted] Pipette.

Picnometer.

Kjeldahl Flask

Porcelain Evaporating Dishes.

the picnometer flask weighed 28,500 grams, stopper included, and held 50.003 grams of distilled water at 15° C. Let the weight of the flask filled with wort be 81.627 grams at 15° C., the flask weighing 28.500 grams, then the wort weighs 53.127 grams, where an equal volume of water weighs 50.003 grams. The result is now obtained by dividing 53.127, the weight of the wort, by 50.003, the weight of the water, equals 1.06248, specific gravity of the wort.

The following abridged formula can be used: Double the weight of wort, or other liquid, and subtract double the excess over 50 grams of the weight of water contained in the picnometer at 15° C., and divide by 100. Taking the preceding case, in which we supposed that the weight of the wort was 53.127 grams, and an equal volume of water weighed 50.003 grams, then,

twice weight of wort = 106,254 grams, less twice excess weight of water 0.006. Divided by 100 = 1.06248, specific gravity of wort.

HYDROMETERS.

Floating instruments used to find the specific gravity of liquids are called hydrometers. They consist of a hollow cylinder of thin metal or glass, having a weight beneath to keep it in an upright position, and a stem above bearing a divided scale. The liquid to be tested is poured into a cylindrical jar, and the instrument immersed. The denser the liquid, the less of it will be displaced by the same hydrometer, and the higher will the instrument rise, whereas it sinks deeper in a liquid of less density, as the instrument displaces exactly its own weight of liquid. When the hydrometer is at rest, the mark on the scale at the liquid level may be read off. There are different kinds of hydrometers bearing different names according to the kinds of liquid for which they are intended. They are known as "acidometers," "alcoholometers," "lactometers," "saccharometers," etc.

THE SACCHAROMETER.

Saccharometers (from the Latin words Saccharum, sugar, and metio, I measure) are a special kind of hydrometers used to find the per cent of sugar in saccharine solutions, and the amount of extract in wort and beer.

The first saccharometer constructed on scientific principles was *made in the year 1787*, by Richardson, in England, and his method

of determining the amount of extract in wort is still in use. He also introduced the term "attenuation" to designate the decrease of the extract during fermentation. Later, Prechtl, in Germany, constructed a saccharometer for a temperature of 12° R., with a scale showing both per cent extract and the corresponding specific gravity figures. In the year 1833 Balling introduced his saccharometer in the form substantially as it is known at present, and Kaiser's per cent areometer appeared in 1838.

If a saccharometer is to be used exclusively for estimating the amount of extract contained in wort or beer, expressed in per cent, it would, of course, seem quite proper to graduate the instrument by dissolving dry extract of malt in water to solutions of known percentages, and immersing the instrument in these solutions, graduating the scale of the saccharometer accordingly. The same results should be obtained by a modification of this plan, according to the methods used by Schultze and Ostermann, and by H. Elion. These investigators determined the specific gravity of a wort, a weighed quantity of which was then evaporated to dryness and dried by Schultze-Ostermann at 70° to 75° C. at ordinary air pressure; by H. Elion at 97° C. in a current of dry air in a partial vacuum.

The English chemists, Brown and Héron, and later, O'Sullivan, determined the specific gravity of solutions of maltose and dextrin, that is, the two principal constituents of wort, in a solution containing 10 g. per 100 c.c. Following the principle of the English investigators, Elion determined how much the specific gravity of water is increased by each gram of dry extract of malt per 100 c.c. of solution.

The results of all these investigations differed considerably on account of the impossibility of getting malt-extract of one and the same composition from different malts, and on account of the difficulty of determining when the extract really was dry, as too high a temperature or too long an exposure was found partly to decompose the extract and thus to influence the results.

For this reason the idea of using dry extract of malt for grading the saccharometer was abandoned, and in its place was selected a substance that differs but little from extract of malt in its specific gravity, and which, on the other hand, can easily be had *in a uniform* degree of dryness and purity. This substance is *pure, dry* cane-sugar. Cane-sugar had already been used by Ball-

ing for the construction of his saccharometer as he supposed that cane-sugar and extract of malt influenced the specific gravity of the solutions in the same way. This is, however, not quite accurate, as a solution of malt-extract shows a slightly higher specific gravity than a solution of cane-sugar of equal percentage. The differences are, however, not great enough seriously to impair the value of such a saccharometer for practical use.

There are, at present, four saccharometers in use, named from their inventors: Balling's, Kaiser's, Long's and Gendar's.

Balling's saccharometer is in general use in the United States, Germany and Austria. It is usually graduated for a temperature of 14° R. (17.5° C.) and at this temperature indicates how many per cent by weight of dry, pure cane-sugar are contained in a sugar solution, and in a wort or beer how many per cent of dry extract the liquid contains. In other words, if the saccharometer, when immersed in a wort, sinks in to the 12 mark, it indicates that one hundred pounds of this wort contains 12 pounds of dry extract of malt.

The line to which the instrument sinks in pure water of 14° R. is marked 0 and is found at the upper part of the stem. The instrument is graded by floating it in sugar solutions of the same temperature, but of different strength, and the depth to which it sinks is marked with the corresponding number of per cent. Balling's saccharometers are generally graded up to 20 or 25 per cent, and each per cent subdivided in tenths.

The indications of the instrument are correct only at the temperature of 14° R. If the solution is warmer than 14° R. the indication is too low, as the liquid becomes less dense at a higher temperature. At a lower temperature the indication would be too high. To avoid the difficulty of always getting the liquid at the same temperature, a correction-scale is added to the instrument, indicating how many tenths of per cent should be added at temperatures higher than 14° R., or subtracted at lower degrees. In this case, the weight at the lower end of the instrument, which serves to float it perpendicularly, is the bulb of a mercury thermometer, the scale of which is inserted in the wider part of the saccharometer, and opposite each degree of temperature is found the corresponding tenth per cent correction.

To obtain correct readings, the instrument must be carefully handled. *It must* be cleaned immediately before being used.

held by the upper end and gradually lowered into the liquid, avoiding dipping it in too deep, as the liquid remaining on the stem above the surface of the liquid would tend to make the instrument heavier. The liquid must be free from foam and no gas bubbles should adhere to the saccharometer, which must float free in the liquid without touching the sides of the vessel. The reading should be done according to the directions on the instrument, and generally from above. Beer must be freed from carbonic acid gas by pouring it from one dish into another repeatedly, and by warming it gently, before it can be weighed by the saccharometer.

Besides the ordinary Balling saccharometer there is in use, especially in sugar factories, the so-called corrected Balling or *Brix* saccharometer. When cane-sugar is dissolved in water a contraction takes place, and this contraction varies with the concentration of the sugar solutions. Brix calculated these contractions and made the corrections correspondingly.

Kaiser's Saccharometers of the modern type are made exactly like Balling's and give the same indications, only the per cent is subdivided in ½, ¼, ⅛ per cent instead of tenths per cent.

Long's Saccharometer is used in England and indicates how many pounds an English barrel (36 gallons) of wort weighs more than a barrel of water at 60° F. (15.6° C.).

Gendar's Saccharometer indicates how many pounds a barrel of beer or wort weighs more than a barrel of water (of 30 gallons) at 70° F. (21.1° C.).

Hot wort saccharometers are, as the name indicates, used to find the per cent of extract in hot wort, and are generally graded at 70° to 75° R. (87.5° to 93.4° C.). These hot wort saccharometers are often made of metal, and are expected to give only an approximately accurate value.

All the above mentioned saccharometers give the amount of extract by weight contained in a certain weight of solution.

Krieger's Extractometer differs from all of them in this respect: It indicates how many grams of cane-sugar (or approximately malt extract) are contained in 100 c.c. of the solution at 14° R.

For the construction of this saccharometer Dr. Jos. Krieger prepared a solution, containing ten grams of cane-sugar in 100 c.c. The specific gravity of this solution at 14° R. was found to be 0.0386, taking water of 14° R. as a unit. As ten grams of cane-

TABLE FOR THE COMPARISON OF DIFFERENT SACCHAROMETERS WITH SPECIFIC GRAVITY, AND GIVING POUNDS OF EXTRACT IN WORT PER BBL. OF 31 GALS.

Kaiser Balling.	Long's.	Gendar's.	Specific Gravity.	Extract per bbl. in lbs.	Kaiser Balling.	Long's.	Gendar's.	Specific Gravity.	Extract per bbl. in lbs
0.00	0.00	0.00	1.000	0.00	12 00	17.45	14.64	1.0488	32.52
.25	.36	.30	1.001	0 65	.25	.83	.96	1.0498	33.23
.50	.72	.60	1.002	1.30	.50	18.21	15.28	1.0509	33.94
.75	1.08	.90	1.003	1.95	.75	.60	.60	1.0520	34.65
1.00	.44	1.20	1.004	2.60	13.00	.99	.92	1.0530	35.36
.25	.80	.50	1.005	3.25	.25	19.38	16.24	1.0540	36.07
.50	2.16	.80	1.006	3.91	.50	.77	.55	1.0551	36.79
.75	.52	2.41	1.007	4.57	.75	20 16	.86	1.0562	37.50
2.00	.88	.40	1.008	5.22	14.00	.55	17.17	1.0572	38.22
.25	3.24	.70	1.009	5.88	.25	.94	.48	1 0582	38.94
.50	.60	3 00	1.010	6.54	.50	21.33	.80	1.0593	39.66
.75	.96	.30	1.011	7.20	.75	.72	18.12	1.0604	40.38
3.00	4.32	.60	1.012	7.86	15.00	22.11	.43	1.0614	41.11
.25	.68	.90	1.013	8.53	.25	.50	.75	1.0625	41.83
.50	5.04	4 20	1.014	9.19	.50	.89	19.07	1.0636	42.55
.75	.40	.50	1.015	9 86	.75	23.27	.39	1.0646	43.28
4.00	.76	.80	1.016	10.52	16.00	.66	.71	1.0657	44.00
.25	6.12	5.10	1.017	11.19	.25	24.05	20.03	1.0668	44.73
.50	.48	.40	1.018	11.86	.50	.44	.35	1.0679	45.46
.75	.84	.70	1.019	12.53	.75	.83	.67	1.0690	46.19
5.00	7.20	6.00	1.020	13.20	17 00	25.21	21.00	1.0700	46.92
.25	.56	.30	1.021	13.87	.25	.61	.33	1.0711	47.66
.50	.92	.60	1.022	14.55	.50	26.00	.66	1.0722	48.39
.75	8.28	.90	1.023	15.22	.75	.39	.99	1.0733	49.13
6.00	.64	7.20	1.024	15.90	18.00	.78	22.32	1.0744	49.86
.25	9.00	.50	1 025	16.58	.25	27.17	.65	1.0755	50.60
.50	.36	.80	1.026	17.26	.50	.56	.98	1.0766	51.34
.75	.72	8.10	1 027	17.94	.75	.96	23.31	1.0777	52.08
7.00	10.08	.40	1.028	18.62	19.00	28.36	.64	1.0788	52.82
.25	.44	.70	1.029	19.30	.25	.76	.97	1.0799	53.57
.50	.80	9.00	1.030	19.99	.50	29.16	24.30	1.0810	54.31
.75	11.16	.30	1.031	20.67	.75	.56	.63	1.0821	55.06
8.00	.52	.60	1.032	21.36	20.00	.95	.96	1.0832	55.80
.25	.96	.96	1.0332	22.05	.25	30.34	25.29	1.0843	56.55
.50	12.32	10 26	1.0342	22.74	.50	.73	.62	1.0854	57.30
.75	.68	.57	1.0352	23.43	.75	31.12	.95	1.0865	58.05
9.00	13.04	.88	1.0363	24.12	21.00	.50	26.27	1.0876	58.80
.25	.40	11.19	1.0374	24.81	.25	.87	.60	1.0887	59 56
.50	.76	.50	1 0384	25.51	.50	32.25	.93	1.0898	60.31
.75	14.12	.81	1.0294	26.20	.75	.64	27.26	1.0909	61.07
10.00	.48	12.11	1.0404	26.90	22.00	33.04	.59	1.0920	61.82
.25	.84	.42	1.0415	27.60	.25	.44	.92	1.0931	62.58
.50	15.21	.73	1.0425	28.30	.50	.84	28.25	1.0942	63.34
.75	.58	13.06	1.0436	29.00	.75	34.23	.58	1.0953	64.10
11.00	.95	.37	1.0446	29.70	23.00	.63	.91	1.0964	64.86
.25	16.32	.68	1.0457	30.41	.25	35.03	29.24	1.0975	65.63
.50	.69	14.00	1.0467	31.11	.50	.43	.57	1.0986	66.39
.75	17.07	.32	1.0478	31.82	.75	.83	.90	1.0997	67.16
					24.00	36.23	30.23	1.1008	67.92

sugar in 100 c.c. had increased the specific gravity of water by 0.0386, one gram of cane-sugar would, consequently, increase the specific gravity by 0.00386. This factor, 0.00386, was used in the construction of the new scale, each degree of which means an increase of 0.00386 in the specific gravity.

The per cent extract of this scale are, therefore, changed into per cent of the Balling scale by dividing them by the sp. gr. of the solution.

The advantages claimed for this scale by Krieger (Der Amerikanische Bierbrauer, 1891, p. 86) are as follows:

1. Taking the weight of a barrel of water as 258 pounds, the weight of a barrel of wort is found by adding the saccharometer reading to 258, or, calling the saccharometer reading Sa,

$$\text{Weight of a barrel of wort} = 258 + \text{Sa}.$$

2. Multiplying 258 by saccharometer reading and dividing by 100 (or cutting off two decimals) gives the pounds of extract per barrel, or

$$\text{pounds extract in one barrel} = \text{Sa} \times 258 \div 100.$$

3. The specific gravity of wort is equal to saccharometer reading multiplied by 0.00386 and added to 1, or

$$\text{Sp. Gr.} = \text{Sa} \times 0.00386 + 1,$$

or, equal saccharometer indication added to 258, and the sum divided by 258, thus:

$$\text{Sp. Gr.} = \text{Sa} + 258 \div 258.$$

4. The alcohol factor remains constant for varying per cents of extracts of original wort, and is equal to 0.4.

While admitting that the claims of Dr. Krieger are valuable it will be seen that the Balling saccharometer can be used, as suggested by R. Wahl, for the purpose of calculating the weight and pounds of extract per barrel, as well as for practical brewery calculations. (See "Figuring in the Brewery," also Der Braumeister, 1890, p. 315).

ALCOHOLOMETERS.

These instruments are used to find the strength of mixtures of alcohol and water.

Tralle's Alcoholometer gives per cent alcohol by volume, or how many volumes of absolute alcohol are contained in 100 volumes of the dilute alcohol at 12.5° R. (15.6° C.). The scale reads from 0 per cent to 100 per cent in absolute alcohol of a specific gravity of 0.7939 at 12.5° R. (15.6° C.).

The indications are correct only in solutions of alcohol in pure water. Corrections on account of temperature are much higher than when using the saccharometer and amount to full per cents. The corrections, however, go the opposite way to those of the saccharometer. The more alcohol is present the less dense is the mixture, and a higher temperature, making it less dense, causes the indications to be too high, and consequently the rule is, for temperatures above 12.5° R., subtract, and for temperatures below 12.5° R., add, as many per cent as indicated by the correction scale.

TESTING THE SACCHAROMETERS.

Saccharometers are usually tested at 0, 5, 10, 15 and 20 per cent. The latter four solutions can be approximately prepared by dissolving 25, 50, 75 and 100 grams of pure, dry cane-sugar in water and weighing each solution up to 500 grams. Testing at 0 is accomplished by immersing the saccharometer in distilled water of a temperature of 14° R. (17.5° C.). In order to determine the correct percentage of extract contained in each of the above sugar solutions, the specific gravity is taken by means of the picnometer and referred to the Balling extract table. The percentage of extract thus obtained should be indicated to within 0.1 per cent by the saccharometer when tested at 14° R. (17.5° C.).

THE BALANCES.

As all analyses are either directly or indirectly based upon the correct indications of the balance, this instrument may be considered as the most important apparatus in the chemical laboratory, and it is necessary that it should be sensitive and accurate to the full limit of its carrying capacity.

ANALYTICAL BALANCE.

The balance can be easily adjusted by the regulating screws, if necessary, and is then ready for testing. This delicate instrument must, when carrying a load of 100 grams (should that be the maximum weight) in each pan, be sufficiently accurate and sensitive to show no change of swing on an interchange of weights, and one milligram added on one side must increase the swing of the needle one or two divisions to the other side.

TECHNICAL BALANCE.

This balance, although not so accurate as the analytical balance, is *nevertheless* a necessity in the chemical laboratory. It is em-

[redacted]

ployed for making such analyses in which the weight exceeds the carrying capacity of a more sensitive balance, or where it is not required to use the milligram weights, for instance, in the determination of the yield and moisture in malt, corn products, rice, barley, etc.

The needle must swing equally far on both sides of the o mark when two kilogram weights are balanced, and also when the same weights change pans. If a centigram weight is added to either pan the needle must show an increased swing of one division of the scale to the opposite side.

Analytical Balance.

TESTING SETS OF WEIGHTS.

Each balance should have a separate set of weights. In correcting a set, proceed as follows: Two 10-milligram weights should be equal; they must counterbalance a 20-milligram weight. The 20-milligram weights must be equal. Two twenties and a ten should counterbalance a 50-milligram weight, etc. Brass weights should never come in contact with acid or other vapors, as their correctness will be impaired. They should never be touched ' the fingers, but always with small pincers.

[redacted]

THE PROCESS OF WEIGHING.

The substance to be weighed is placed on the left scale, and the other scale is accurately counter-poised against it. In counter-poising substances on the balance, a systematic course ought to be pursued. The following is an illustration: Suppose we want to weigh a crucible, the weight of which was subsequently found to be 7.727 grams; say 10 grams is placed on the other scale against it, we find this is too much; we place the weight next in succession, i. e., five grams, and find this too little; next eight, too much; seven, too little; 7.5, too little; 7.7, too little; 7.8, too much; 7.75, too much; 7.72, too little; 7.73, too much; 7.725, too little; 7.727, right.

TESTING PIPETTES.

To test 25 c.c. Pipettes and Burettes.—Put a beaker on one pan of the scale and counterbalance it on the other. Run 25 c.c.

Technical Balance.

of distilled water at 15° C. into this beaker and weigh it. The pipette is pronounced correct if the weight is within 5 centigrams of 25 grams. Proceed in the same way with the other pipettes.

Burettes are tested in the same way.

To test 100 c.c. Flasks.—Wash a 100 c.c. flask with water, then with alcohol, and dry. Counterbalance the flask and fill to mark with distilled water of 15° C. It should then weigh to within 5 decigrams of 100 grams. Proceed similarly for 50 c.c., 200 c.c., 250 c.c., ½ liter, and 1 liter flasks.

THE THERMOMETER.

This consists of a bulb connected with a tube of uniform bore, and partly filled with mercury or alcohol. The upper part of the tube is exhausted of air and closed air-tight. If the instrument is brought in contact with a warmer body, both the glass and the liquid of the thermometer expand, but, as the expansion of the glass is small compared to that of the liquid, the latter will begin to rise in the tube. The change in volume is measured on a scale attached to the tube. Mercury freezes, or becomes solid, at low temperatures, and for still lower ones the alcohol thermometer is used.

"Thermometer Scales." A thermometer has two fixed points, called the freezing point and the boiling point. The first is the temperature of melting ice, the other the temperature of steam escaping from water boiling under normal atmospheric pressure. The distance between these two points is divided into equal parts, called degrees, which vary in the different scales.

STANDARD SCALES.

There are three of these scales in use, viz.:

"Fahrenheit," "Reaumur" and "Celsius" or "Centigrade." The boiling point is called: on the Fahrenheit, 212; on the Reaumur, 80; and on the Centigrade, 100. The freezing point is called: on the Fahrenheit, 32; on the Reaumur, 0; and on the Centigrade, 0. Between the freezing and boiling points there are on the Fahrenheit, 212 — 32, or 180 degrees; on the Reaumur 80 degrees; and on the Centigrade, 100 degrees.

To Reduce Degrees of One Scale to Those of Another.—The same rise in temperature, from the freezing to the boiling point of water, being divided into 180 degrees on the Fahrenheit, 80 degrees on the Reaumur, and 100 degrees on the Centigrade thermometer, it follows that 180 degrees Fahrenheit (written 180° F.) = 80 degrees Reaumur (80° R.) = 100 degrees Centigrade (100° C.) = or, dividing by 20, that 9° F. = 4° R. = 5° C.;

and $1^\circ \text{ F.} = \frac{4}{9}{}^\circ \text{ R.} = \frac{5}{9}{}^\circ \text{ C.}$; $1^\circ \text{ R.} = \frac{9}{4}{}^\circ \text{ F.} = \frac{5}{4}{}^\circ \text{ C.}$; $1^\circ \text{ C.} = \frac{9}{5} \text{ F.} = \frac{4}{5} \text{ R.}$

And since the point marked 32° F. corresponds to 0° R. and 0° C., we may reduce Reaumur degrees to Fahrenheit by multiplying by 9, dividing by 4 and adding 32; and Centigrade degrees to Fahrenheit by multiplying by 9, dividing by 5 and adding 32.

Thus:

$$30^\circ \text{ R.} = \frac{30 \times 9}{4} + 32, \text{ or } \frac{270}{4} + 32, \text{ or } 67.5 + 32, \text{ or } 99.5^\circ \text{ F.}$$

$$30^\circ \text{ C.} = \frac{30 \times 9}{5} + 32, \text{ or } 54 + 32, \text{ or } 86^\circ \text{ F.}$$

Similarly, we may reduce Fahrenheit degrees to Reaumur by subtracting 32, multiplying by 4 and dividing by 9; and Fahrenheit degrees to Centigrade by subtracting 32, multiplying by 5 and dividing by 9. Thus:

$$60^\circ \text{ F.} = \frac{4\,(60 - 32)}{9}, \text{ or } \frac{4 \times 28}{9}, \text{ or } \frac{112}{9}, \text{ or } 12.44^\circ \text{ R.}$$

$$60^\circ \text{ F.} = \frac{5\,(60 - 32)}{9}, \text{ or } \frac{5 \times 28}{9}, \text{ or } \frac{140}{9} \text{ or } 15.55^\circ \text{ C.}$$

TESTING THE THERMOMETERS.

The accuracy of a thermometer at the boiling and freezing points of water may be ascertained approximately in the following manner: Immerse the thermometer in boiling water, care being taken not to touch the sides of the vessel containing the water or to have the mercury bulb come in contact with the bottom of the vessel. The thermometer after a few minutes should read 212° on the Fahrenheit scale, 100° on the Celsius and 80° on the Reaumur. For the freezing point immerse the thermometer in melting ice. It should then indicate 32° F., 0° C., 0° R.

WORTS.

The wort is filtered while cold. Note the color, brilliancy, presence or absence of starch or erythrodextrin.

EXTRACT.

The specific gravity is taken by means of the picnometer at 15° C. and converted into per cent extract by referring to the *Balling table.*

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CONVERSION TABLES OF THE THERMOMETER SCALES.

Fahrenheit to Reaumur and Celsius.

F.	R.	C.	F.	R.	C.	F.	R.	C.	F.	R.	C.
°	°	°	°	°	°	°	°	°	°	°	°
212	80.0	100	148	51.6	64.4	84	23.1	28.9	20	−5.3	−6.7
211	79.6	99.4	147	51.1	63.9	83	22.7	28.3	19	−5.8	−7.2
210	79.1	98.9	146	50.7	63.3	82	22.2	27.8	18	−6.2	−7.8
209	78.7	98.3	145	50.2	62.8	81	21.8	27.2	17	−6.7	−8.3
208	78.2	97.8	144	49.8	62.2	80	21.3	26.7	16	−7.1	−8.9
207	77.8	97.2	143	49.3	61.7	79	20.9	26.1	15	−7.6	−9.4
206	77.3	96.7	142	48.9	61.1	78	20.4	25.6	14	−8.0	−10.0
205	76.9	96.1	141	48.4	60.6	77	20.0	25.0	13	−8.4	−10.6
204	76.4	95.6	140	48.0	60.0	76	19.6	24.4	12	−8.9	−11.1
203	76.0	95.0	139	47.6	59.4	75	19.1	23.9	11	−9.3	−11.7
202	75.6	94.4	138	47.1	58.9	74	18.7	23.3	10	−9.8	−12.2
201	75.1	93.9	137	46.7	58.3	73	18.2	22.8	9	−10.2	−12.8
200	74.7	93.3	136	46.2	57.8	72	17.8	22.2	8	−10.7	−13.3
199	74.2	92.8	135	45.8	57.2	71	17.3	21.7	7	−11.1	−13.9
198	73.8	92.2	134	45.3	56.7	70	16.9	21.1	6	−11.6	−14.4
197	73.3	91.7	133	44.9	56.1	69	16.4	20.6	5	−12.0	−15.0
196	72.9	91.1	132	44.4	55.6	68	16.0	20.0	4	−12.4	−15.6
195	72.4	90.6	131	44.0	55.0	67	15.6	19.4	3	−12.9	−16.1
194	72.0	90.0	130	43.6	54.4	66	15.1	18.9	2	−13.3	−16.7
193	71.6	89.4	129	43.1	53.9	65	14.7	18.3	1	−13.8	−17.2
192	71.1	88.9	128	42.7	53.3	64	14.2	17.8	0	−14.2	−17.8
191	70.7	88.3	127	42.2	52.8	63	13.8	17.2	−1	−14.7	−18.3
190	70.2	87.8	126	41.8	52.2	62	13.3	16.7	−2	−15.1	−18.9
189	69.8	87.2	125	41.3	51.7	61	12.9	16.1	−3	−15.6	−19.4
188	69.3	86.7	124	40.9	51.1	60	12.4	15.6	−4	−16.0	−20.0
187	68.9	86.1	123	40.4	50.6	59	12.0	15.0	−5	−16.4	−20.6
186	68.4	85.6	122	40.0	50.0	58	11.6	14.4	−6	−16.9	−21.1
185	68.0	85.0	121	39.6	49.4	57	11.1	13.9	−7	−17.3	−21.7
184	67.6	84.4	120	39.1	48.9	56	10.7	13.3	−8	−17.8	−22.2
183	67.1	83.9	119	38.7	48.3	55	10.2	12.8	−9	−18.2	−22.8
182	66.7	83.3	118	38.2	47.8	54	9.8	12.2	−10	−18.7	−23.3
181	66.2	82.8	117	37.8	47.2	53	9.3	11.7	−11	−19.1	−23.9
180	65.8	82.2	116	37.3	46.7	52	8.9	11.1	−12	−19.6	−24.4
179	65.3	81.7	115	36.9	46.1	51	8.4	10.6	−13	−20.0	−25.0
178	64.9	81.1	114	36.4	45.6	50	8.0	10.0	−14	−20.4	−25.6
177	64.4	80.6	113	36.0	45.0	49	7.6	9.4	−15	−20.9	−26.1
176	64.0	80.0	112	35.6	44.4	48	7.1	8.9	−16	−21.3	−26.7
175	63.6	79.4	111	35.1	43.9	47	6.7	8.3	−17	−21.8	−27.2
174	63.1	78.9	110	34.7	43.3	46	6.2	7.8	−18	−22.2	−27.8
173	62.7	78.3	109	34.2	42.8	45	5.8	7.2	−19	−22.7	−28.3
172	62.2	77.8	108	33.8	42.2	44	5.3	6.7	−20	−23.1	−28.9
171	61.8	77.2	107	33.3	41.7	43	4.9	6.1	−21	−23.6	−29.4
170	61.3	76.7	106	32.9	41.1	42	4.4	5.6	−22	−24.0	−30.0
169	60.9	76.1	105	32.4	40.6	41	4.0	5.0	−23	−24.4	−30.6
168	60.4	75.6	104	32.0	40.0	40	3.6	4.4	−24	−24.9	−31.1
167	60.0	75.0	103	31.6	39.4	39	3.1	3.9	−25	−25.3	−31.7
166	59.6	74.4	102	31.1	38.9	38	2.7	3.3	−26	−25.8	−32.2
165	59.1	73.9	101	30.7	38.3	37	2.2	2.8	−27	−26.2	−32.8
164	58.7	73.3	100	30.2	37.8	36	1.8	2.2	−28	−26.7	−33.3
163	58.2	72.8	99	29.8	37.2	35	1.3	1.7	−29	−27.1	−33.9
162	57.8	72.2	98	29.3	36.7	34	0.9	1.1	−30	−27.6	−34.4
161	57.3	71.7	97	28.9	36.1	33	0.4	0.6	−31	−28.0	−35.0
160	56.9	71.1	96	28.4	35.6	32	0.0	0.0	−32	−28.4	−35.6
159	56.4	70.6	95	28.0	35.0	31	−0.4	−0.6	−33	−28.9	−36.1
158	56.0	70.0	94	27.6	34.4	30	−0.9	−1.1	−34	−29.3	−36.7
157	55.6	69.4	93	27.1	33.9	29	−1.3	−1.7	−35	−29.8	−37.2
156	55.1	68.9	92	26.7	33.3	28	−1.8	−2.2	−36	−30.2	−37.8
155	54.7	68.3	91	26.2	32.8	27	−2.2	−2.8	−37	−30.7	−38.3
154	54.2	67.8	90	25.8	32.2	26	−2.7	−3.3	−38	−31.1	−38.9
153	53.8	67.2	89	25.3	31.7	25	−3.1	−3.9	−39	−31.6	−39.4
152	53.3	66.7	88	24.9	31.1	24	−3.6	−4.4	−40	−32.0	−40.0
151	52.9	66.1	87	24.4	30.6	23	−4.0	−5.0			
	52.4	65.6	86	24.0	30.0	22	−4.4	−5.6			
	52.0	65.0	85	23.6	29.4	21	−4.9	−6.1			

CONVERSION TABLES OF THE THERMOMETER SCALES.

Reaumur to Fahrenheit and Celsius.

R. °	F. °	C. °	R. °	F. °	C. °	R. °	F. °	C. °	R. °	F. °	C. °
80	212.00	100.00	49	142.25	61.25	18	72.50	22.50	—13	2.75	—16.25
79	209.75	98.75	48	140.00	60.00	17	70.25	21.25	—14	0.50	—17.50
78	207.50	97.50	47	137.75	58.75	16	68.00	20.00	—15	— 1.75	—18.75
77	205.25	96.25	46	135.50	57.50	15	65.75	18.75	—16	— 4.00	—20.00
76	203.00	95.00	45	133.25	56.25	14	63.50	17.50	—17	— 6.25	—21.25
75	200.75	93.75	44	131.00	55.00	13	61.25	16.25	—18	— 8.50	—22.50
74	198.50	92.50	43	128.75	53.75	12	59.00	15.00	—19	—10.75	—23.75
73	196.25	91.25	42	126.50	52.50	11	56.75	13.75	—20	—13.00	—25.00
72	194.00	90.00	41	124.25	51.25	10	54.50	12.50	—21	—15.25	—26.25
71	191.75	88.75	40	122.00	50.00	9	52 25	11.25	—22	—17.50	—27.50
70	189.50	87.50	39	119.75	48.75	8	50.00	10.00	—23	—19.75	—28.75
69	187.25	86.25	38	117.50	47.50	7	47.75	8.75	—24	—22.00	—30.00
68	185.00	85.00	37	115.25	46.25	6	45.50	7.50	—25	—24.25	—31.25
67	182.75	83.75	36	113.00	45.00	5	43.25	6.25	—26	—26.50	—32.50
66	180.50	82.50	35	110.75	43.75	4	41 00	5.00	—27	—28.75	—33.75
65	178.25	81.25	34	108.50	42.50	3	38.75	3.75	—28	—31.00	—35.00
64	176.00	80.00	33	106.25	41.25	2	36.50	2.50	—29	—33.25	—36.25
63	173.75	78.75	32	104.00	40.00	1	34.25	1.25	—30	—35.50	—37.50
62	171.50	77 50	31	101.75	38.75	0	32.00	0.00	—31	—37.75	—38.75
61	169.25	76.25	30	99.50	37.50	— 1	29.75	— 1.25	—32	—40.00	—40.00
60	167.00	75.00	29	97.25	36.25	— 2	27.50	— 2.50	—33	—42.25	—41.25
59	164.75	73.75	28	95.00	35.00	— 3	25.25	— 3.75	—34	—44.50	—42.50
58	162.50	72.50	27	92.75	33.75	— 4	23.00	— 5.00	—35	—46.75	—43.75
57	160.25	71.25	26	90.50	32.50	— 5	20.75	— 6.25	—36	—49.00	—45.00
56	158.00	70.00	25	88.25	31.25	— 6	18.50	— 7.50	—37	—51.25	—46.25
55	155.75	68.75	24	86.00	30.00	— 7	16.25	— 8 75	—38	—53.50	—47.50
54	153.50	67.50	23	83.75	28.75	— 8	14.00	—10.00	—39	—55.75	—48.75
53	151.25	66.25	22	81.50	27.50	— 9	11.75	—11.25	—40	—58.00	—50.00
52	149.00	65.00	21	79.25	26.25	—10	9.50	—12.50			
51	146.75	63.75	20	77.00	25.00	—11	7.25	—13.75			
50	144.50	62.50	19	74.75	23.75	—12	5.00	—15.00			

Celsius to Reaumur and Fahrenheit.

C. °	R. °	F. °	C. °	R. °	F. °	C. °	R. °	F. °	C. °	R. °	F. °
100	80.0	212.0	72	57.6	161.6	44	35.2	111.2	16	12.8	60.8
99	79.2	210.2	71	56.8	159.8	43	34.4	109.4	15	12.0	59.0
98	78.4	208.4	70	56.0	158.0	42	33.6	107.6	14	11.2	57.2
97	77.6	206.6	69	55.2	156.2	41	32.8	105.8	13	10.4	55.5
96	76.8	204.8	68	54.4	154.4	40	32.0	104.0	12	9.6	53.6
95	76.0	203.0	67	53.6	152.6	39	31.2	102.2	11	8.8	51.8
94	75.2	201.2	66	52.8	150.8	38	30.4	100.4	10	8.0	50 0
93	74.4	199.4	65	52.0	149.0	37	29.6	98.6	9	7.2	48.2
92	73.6	197.6	64	51.2	147.2	36	28.8	96.8	8	6.4	46.4
91	72.8	195.8	63	50.4	145.4	35	28.0	95.0	7	5.6	44.6
90	72.0	194.0	62	49.6	143.6	34	27.2	93.2	6	4.8	42.8
89	71.2	192.2	61	48.8	141.8	33	26.4	91.4	5	4.0	41.0
88	70.4	190.4	60	48.0	140.0	32	25.6	89.6	4	3.2	39.2
87	69.6	188.6	59	47.2	138.2	31	24.8	87.8	3	2.4	37.4
86	68.8	186.8	58	46.4	136.4	30	24.0	86.0	2	1.6	35.6
85	68.0	185.0	57	45.6	134.6	29	23.2	84.2	1	0.8	33.8
84	67.2	183.2	56	44.8	132.8	28	22.4	82.4	0	0.0	32.0
83	66.4	181.4	55	44.0	131.0	27	21.6	80.6	—1	— 0.8	30.2
82	65.6	179.6	54	43.2	129.2	26	20.8	78.8	—2	—1.6	28.4
81	64.8	177.8	53	42.4	127.4	25	20.0	77.0	—3	—2.4	26.6
80	64.0	176.0	52	41.6	125.6	24	19.2	75.2	—4	—3.2	24.8
79	63.2	174.2	51	40.8	123.8	23	18.4	73.4	5	—4.0	23.0
78	62.4	172.4	50	40.0	122.0	22	17.6	71.6	— 6	—4.8	21.2
77	61.6	170.6	49	39.2	120.2	21	16.8	69.8	—7	— 5.6	19.4
76	60.8	168.8	48	38.4	118.4	20	16.0	68.0	—8	—6.4	17.6
75	60.0	167.0	47	37.6	116.6	19	15.2	66.2	—9	—7.2	15.8
74	59.2	165.2	46	36.8	114.8	18	14.4	64.4	—10	—8.0	14.[illegible]
73	58.4	163.4	45	36.0	113.0	17	13.6	62.6	—11	—8.8	12.[illegible]

REDUCING SUGARS (SUGAR).

Measure 25 c.c. of the wort and dilute to 250 c.c. After shaking thoroughly, run 25 c.c. of this mixture into a boiling Fehling solution and boil four minutes. Treat the red precipitate as in the case of sugar determination in beer. Subtract three milligrams (0.003 g.) from the total oxide of copper found; multiply by 28.3, and divide by the specific gravity of the wort. The result is the percentage of reducing sugars (sugar) in the wort.

Volumetric Estimation of sugars and calculation of sugar degree.—The wort or beer should be diluted, if necessary, so that it contains not to exceed 1 per cent of sugar. Suppose the wort has 9.512 per cent extract. Dilute it 10 times by measuring out 10 c.c. of the wort and adding 90 c.c. of water. After mixing thoroughly, fill a 50 c.c. burette with the diluted wort. Prepare a Fehling solution in a porcelain dish by mixing 10 c.c. of the white solution, 10 c.c. of the blue solution and 20 c.c. of water. Heat to boiling and add the diluted wort, first in large quantities, finally, in 0.1 c.c., until the blue color disappears. This point being difficult to discover by the eye, it is better to moisten a piece of doubled filter paper on each side with a drop of dilute acetic acid and a drop of a solution of ferrocyanide of potash, then add on the top side a drop of the solution from the porcelain dish; press the spot between the fingers a little, and examine the under side. This is repeated after each addition of 0.1 c.c. of diluted wort to the solution in the porcelain dish, each time putting on a fresh drop of the dilute acetic acid and the solution of ferrocyanide of potash on each side of the doubled filter paper and one drop of the solution from the porcelain dish on the top side. As long as there is any copper left unprecipitated, the under side of the doubled filter paper remains colored red. Keep adding 0.1 c.c. of the diluted wort to the solution in the porcelain dish and put the drops on the filter paper as described until this red color on the under side of the doubled filter paper disappears, or the paper remains white. At this point all of the copper has been precipitated as oxide of copper. The number of c.c. of diluted wort that has been run into the Fehling solution is now noted. Suppose we find it to be 22 c.c. Since it requires 155 *milligrams* of sugar to precipitate all of the copper in the *Fehling solution* these 22 c.c. of diluted wort contained 155 *milligrams of* maltose.

Or 22 c.c. of diluted wort contain 0.155 g. sugar.
100 c.c. of diluted wort contain 0.7 g. sugar.

or

$$\frac{0.155 \text{ g.} \times 100}{22} = 0.7 \text{ grams sugar.}$$

In the original wort, which is 10 times stronger, there must, then, be seven grams sugar. The wort of 9.512 per cent extract has a specific gravity of 1.0384, and dividing 7 by 1.0384 gives 6.74, the percentage of sugar or maltose in the wort. The *Sugar Degree* (sugar in 100 parts) is then found as follows:

In 9.512 parts extract are contained 6.74 sugar, or
In 100 parts extract are contained how many parts?

$$\text{Sugar Degree} = \frac{6.74 \times 100}{9.512} = 71.$$

Ratio of Sugar to Non-sugar.—By subtracting the sugar from the extract we find the non-sugar, from which data we can readily find the ratio between the two, taking sugar as 100.

$$\frac{2.772 \times 100}{6.74} = 41.1 \text{ or S : NS.} = 100 : 41.1.$$

ALBUMEN.

Measure out 25 c.c. of the wort into a Kjeldahl flask and add a small amount of tannic acid to prevent frothing. Evaporate to a syrupy consistency on a sand bath. When cool, add about 0.7 gram of yellow mercuric oxide and 20 c.c. of concentrated chemically pure sulphuric acid. Continue as under albuminoid determination in beer, using the same factor, 0.035 in the calculation and divide by the specific gravity.

BEERS.

DETERMINATION OF APPARENT EXTRACT.

Remove the carbonic acid by repeated pouring from one large copper beaker into another, and take the specific gravity by means of a picnometer at 15° C. Refer the specific gravity found to Balling's table, and read off the apparent extract of the beer, the "Balling of beer."

ALCOHOL AND REAL EXTRACT.

Weigh two thoroughly cleaned and dried Erlenmeyer flasks (about 250 c.c. capacity). Into one weigh exactly 100 grams

of the beer, free from carbonic acid, and add 50 c.c. of distilled water. Connect with a condenser, and distill about 80-90 c.c. of the diluted beer into the second, previously weighed, cleaned and dried Erlenmeyer flask. After cooling, fill up both flasks, adding carefully distilled water from a wash bottle, to a weight of 100 grams over and above the weight of the empty flasks. Take the specific gravity of each with the picnometer, and then refer to Balling's extract tables and Baumhauer's alcohol tables (15° C.) to obtain the respective per cents, by weight, of real extract and alcohol. By subtracting the apparent extract from the real extract and multiplying by 2.22 the approximate percentage of alcohol is obtained, which may serve as a check on the results.

The following method, although not as accurate as the preceding one, will serve in cases where the approximate percentage of alcohol is desired. After the beer has been freed from carbonic acid, determine the apparent extract by means of the saccharometer; 200 g. is now weighed in a copper beaker, using the technical balance. Heat to boiling and allow to boil until about one-third of the volume remains. Cool and add enough water to make the original weight, i. e., 200 g. plus the weight of the empty beaker. After mixing thoroughly, again determine the Balling by means of a saccharometer which then shows the real extract of the beer. The approximate percentage of alcohol is then obtained by subtracting the apparent from the real extract of the beer and multiplying by the factor 2.22.

FIXED ACID.

Measure 50 c.c. of the extract solution obtained as above described (after determining the specific gravity), in a small beaker, and titrate with decinormal caustic soda solution, until a drop no longer gives a reddish tinge to blue litmus paper. Multiply the number of c.c. standard soda used by 0.018 to get the percentage of fixed acid in the beer.

VOLATILE ACID.

Measure 50 c.c. of the above obtained alcohol distillate in a small beaker and add enough tincture of cochineal to give a decided yellow color. Run in a decinormal solution of caustic soda from a burette, one-tenth c.c. at a time, until a reddish color appears. The number of one-tenth c.c. used multiplied by 0.0012 gives the percentage of volatile acid in beer.

PHOSPHORIC ACID.

Measure out 50 c.c. of the original beer, free from carbonic acid, into a small beaker. Add ·5 c.c. of an acid solution of sodium acetate, and heat to boiling. Run in from a burette standard uranium acetate solution, one-half c.c. at a time, testing each time until a drop of the beer, when placed on a white plate, colors a small crystal of potassium ferrocyanide slightly brown. The number of c.c. of the uranium acetate solution necessary, multiplied by 0.01, gives the per cent of phosphoric acid (anhydride) in the beer.

TOTAL ALBUMEN.

Measure out 25 c.c. of the beer, free from carbonic acid, into a Kjeldahl flask. Evaporate to a syrupy consistentcy on a sand bath. When cool, add about 0.7 gram of yellow mer-

Wash Bottle.

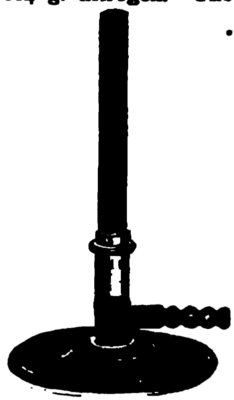
Beakers (different sizes).

curic oxide, and 20 c.c. of concentrated chemically pure sulphuric acid. Heat again on a sand bath, in a hood, until almost colorless. Add to the somewhat cooled liquid gradually small quantities of powdered, chemically pure permanganate of potash, until a green color remains upon stirring, and allow to cool. Fill a half-liter Erlenmeyer flask to a depth of about half an inch with distilled water, and run in the contents of the Kjeldahl flask, carefully rinsing with distilled water. Add 10 c.c. sulphide of potassium solution and one or two pieces of pure granulated zinc to prevent bumping. Add enough caustic soda solution (free from nitrogen) to make it alkaline (about 70 to 80 c.c. of a saturated

solution). Connect immediately with Liebig's condenser and distill over about 100 to 150 c.c.; the distillate is collected in a quarter-liter Erlenmeyer flask, containing 25 c.c. of decinormal sulphuric acid. In order to prevent any loss of ammonia, the end of the tube of Liebig's condenser should be immersed in the acid before commencing the distillation. Titrate back the excess of sulphuric acid with decinormal sodium hydrate solution, using cochineal as an indicator. Subtract the number of c.c. of decinormal sodium hydrate used, from 24.5, multiply the remainder by 0.035, and divide by the specific gravity of the beer, to obtain the per cent of total albumen.

Explanation of the factor 0.035.—One c.c. of the one-tenth standard soda solution corresponds to 0.0014 g. nitrogen. The

Drying Oven.



Bunsen Burner.

nitrogen, when multiplied by the factor 6.25, gives the albumen. As the albumen was determined in 25 c.c. of beer, it would be four times more in 100 c.c.; therefore

$$0.0014 \times 6.25 \times 4 = 0.035.$$

REDUCING SUGARS (MALTOSE).

Measure out 25 c.c. of the beer free from carbonic acid into a 100 c.c flask, and add distilled water up to the mark. After shaking thoroughly, prepare a Fehling solution in a glass beaker of about 300 c.c. capacity, by mixing 30 c.c. of the blue solution, 30 c.c. of the white, and 60 c.c. distilled water. Heat to boiling and then run in immediately from a pipette 25 c.c.

of the diluted beer, and allow to boil for four minutes. Filter the red precipitate of oxide of copper, while hot, through an ashless filter paper, and transfer carefully any particles of the red precipitate that may adhere to the sides of the beaker to the filter by washing with hot water. Continue washing with boiling water until the sides or rim of the filter paper show no longer an alkaline reaction by testing with red litmus paper. Dry in a hot air bath at 100 to 105° C., and ignite in a weighed platinum crucible, cool and weigh. The increase in weight, minus 0.003 g., gives the amount of oxide of copper. To find the percentage of maltose in the beer, multiply the number of grams of oxide of copper by the factor 11.32 and divide by the specific gravity of the beer.

The factor 11.32 is found in the following manner: 25 c.c. beer diluted to 100 c.c. = 4 times diluted; as the maltose was determined in 25 c.c. of the diluted beer, then the total dilution = 4 × 4 or 16 times. The oxide of copper is calculated as copper by multiplying by 0.8. This result divided by the factor 1.13 = maltose; therefore,

$$\frac{16 \times 0.8}{1.13} = 11.32.$$

The subtraction of the three milligrams from the total oxide of copper is an allowance for the alkali, which it is impossible to wash out.

ASH.

Evaporate to dryness on a water bath 100 grams of the beer in a platinum dish of known weight. Ignite directly over a Bunsen burner until the ash assumes a white appearance. Cool in desiccator, and weigh. The weight of ash in grams gives the per cent of ash in the beer.

DEXTRIN.

Fifty c.c. beer and 15 c.c. hydrochloric acid of specific gravity 1.125 are diluted to 200 c.c. The flask, after being fitted with a wide glass tube about three feet long, is kept in the boiling water bath for two hours, cooled, neutralized with caustic soda and filled to 250 c.c. (or 300 c.c. with a beer of high extract); 25 c.c. of this diluted solution is taken and run into a boiling Fehling solution (30 c.c. blue, 30 c.c. white, 60 c.c. water), and al-

lowed to boil for two minutes. Filter, and determine the amount of oxide of copper, as in maltose determination in beer. Multiply the oxide of copper found by 0.8 to obtain the corresponding amount of copper, and refer to F. Allihn's dextrose table. The amount of dextrose thus found, multiplied by 20 (or 24 if diluted to 300 c.c.) and divided by the specific gravity, equals the dextrose in the liquid. Take this percentage of dextrose, subtract [illegible] of the percentage of maltose in the original beer, and multiply by $\frac{9}{10}$ which gives the percentage of dextrin in the original beer.

WATER ANALYSIS.

TOTAL SOLIDS.

Evaporate to dryness on a water bath 200 c.c. of the sample in a weighed platinum dish. Dry in the hot air bath at 105-110° C., until no further diminution of weight takes place. Subtract the weight of the empty dish and multiply by 5. The result is the total amount of the solids in milligrams per liter, or parts per million.

LOSS BY IGNITION.

Heat the contents of the platinum dish to a dull redness. In case it blackens (which is an indication of organic matter), continue heating gently until it appears white. Cool, moisten with an ammonium carbonate solution, and evaporate to dryness on a water bath. Heat gently over a Bunsen burner and cool in a desiccator. Weigh and multiply the loss in weight by 5. Result is the loss due to ignition.

TOTAL SULPHATES.

Treat the ignited residue with a small amount of water and add, carefully, dilute sulphuric acid (1:4) in moderate excess. Evaporate to dryness on a sand bath and then heat directly over a Bunsen burner in order to expel all the free sulphuric acid. Cool in a desiccator and weigh. Multiply by 5 to obtain milligrams per liter or parts per million of the sulphates of all the bases. When dissolved in water the total sulphates so obtained must show a neutral reaction.

OXIDES OF IRON AND ALUMINUM.

Acidify 200 c.c. of the water with 1 c.c. of reagent hydrochloric acid, and concentrate to about ⅙ of the original volume, then add enough ammonium hydrate (aqua ammonia) to render the

solution slightly alkaline. Should a precipitate form, redissolve in hydrochloric acid and reprecipitate with ammonia and evaporate until the odor of ammonia has almost entirely disappeared. If iron and aluminum are present, the former can be distinguished by its rust-colored appearance. Filter (the filtrate still contains the calcium, magnesium and sodium salts) through an ashless filter paper into a medium-sized beaker. Wash the precipitate that may adhere to the sides of the beaker with hot water, and transfer to filter. Continue washing the precipitate with hot water until a few drops of the filtrate, when collected in a test tube, show no turbidity upon adding a few drops of silver nitrate solution.

Concentrate the filtrate and washings to about 50 c.c., and reserve for the calcium and magnesium determinations. Dry the precipitate in the hot air bath, and then carefully burn in a weighed platinum or porcelain crucible. Cool in a desiccator and weigh again. The increase in weight shows the number of milligrams of oxides of iron and aluminum in 200 c.c. of water. Multiplied by 5, gives the parts of oxides of iron and aluminum per million.

OXIDE OF CALCIUM.

The above mentioned filtrate, which was concentrated to about 50 c.c., should be kept hot, add a few c.c. of ammonium chloride solution and then 5 to 10 c.c. ammonium oxalate solution, and place on water bath until the precipitate has settled. Then add carefully a few drops more of the ammonium oxalate solution to be sure that all the calcium was precipitated. If it was, no further precipitate will be produced. The solution containing the white precipitate (which is calcium oxalate) is now filtered through an ashless filter paper into a 200 c.c. beaker. Wash the precipitate with hot water and transfer to filter; continue washing until a few drops of the filtrate, when collected in a test tube and treated with a solution of nitrate of silver, remains clear. The filtrate and washings are now concentrated to about 50 c.c., and reserved for the magnesium determination. The precipitate is dried in a hot air bath, burned in a weighed platinum or porcelain crucible over a Bunsen burner, and then in the flame of a blast lamp until the weight remains constant. The weight of the substance in milligrams multiplied by 5 gives the number of parts *of oxide of calcium* per million.

MAGNESIUM OXIDE.

Determined as magnesium pyrophosphate.—To the filtrate from calcium oxalate, which was concentrated to 50 c.c., add a few c.c. of ammonium chloride solution, if not added already when precipitating the lime, and a slight excess of ammonia. (Should a precipitate form upon the addition of ammonia, it would indicate that not enough ammonium chloride had been used, in which case enough is added to effect the re-solution of the precipitate formed.) To the clear liquid is added sodium phosphate solution and the mixture stirred, then add dilute (1:3) ammonia gradually to the amount of ⅙ of the liquid. Cover and allow to stand for 12 hours. Filter through an ashless filter paper, and wash out any particles of the precipitate that may adhere to the sides of the beaker, with a portion of the filtrate, or dilute ammonia. The precipitate is now washed with a mixture of 3 parts of water, and one part solution of ammonia of 0.96 specific gravity, the operation being continued until a few drops of the liquid passing through the filter when acidified with nitric acid, produces only a slight milky color upon the addition of a drop of silver nitrate solution. The precipitate is now thoroughly dried in a hot air bath of 105-110° C., and then transferred to a weighed platinum or porcelain crucible. Heat gently at first, and finally to intense redness; continue the heating over a blast lamp for about five minutes, cool and weigh.

If the magnesium pyrophosphate is dark colored, moisten with a few drops of nitric acid, warm carefully till dry, and ignite again, cool and weigh. The weight of the magnesium pyrophosphate $\times$ 0.36 gives the weight of magnesium oxide in 200 c.c.; the weight of magnesium oxide in milligrams $\times$ 5 gives parts of magnesium oxide per million.

SULPHURIC ANHYDRIDE.

Determined as barium sulphate.—Measure out 200 c.c. of the water into a beaker of about 400 c.c. capacity, acidify by adding 1 c.c. of hydrochloric acid and evaporate to about 50 c.c., add to the hot liquid a solution of barium chloride (8-10 c.c.), proceed then as in the determination of sulphuric acid as described under preparation of sulphuric acid. The weight of barium sulphate $\times$ 0.343 $\times$ 5 gives the weight of sulphuric anhydride in milligrams per liter or parts per million.

CHLORINE.

Measure out 100 c.c. of the water into a beaker of about 200 c.c. capacity, add 3 drops of a solution of pure potassium chromate. Then run from a burette a decinormal silver nitrate solution very slowly, stirring constantly. Each drop produces, where it falls, a red spot, which, upon stirring, disappears. Continue to add the silver nitrate drop by drop, until the red coloration ceases to disappear, and note the number of c.c. it required. 1 c.c. of the decinormal silver nitrate solution $=$ 0.00585 gram of sodium chloride, or 0.00355 gram chlorine. Suppose it required 0.5 c.c. of silver nitrate solution, then $0.00355 \times 0.5 =$ 0.001775, amount of chlorine in 100 c.c., or 17.75 in 1,000 c.c., or milligrams per liter. Milligrams per liter and parts per million being identical, then the parts per million of chlorine in this case would be 17.75.

FREE AMMONIA.

Take 200 c.c. of the water in an Erlenmeyer flask. Add about one gram of pure, dry, sodium carbonate, and distill through a Liebig condenser into a 50 c.c. Nessler tube. Two c.c. of Nessler reagent are dropped into the 50 c.c. of distillate, and if any ammonia is present it will assume a rich brown color; the more ammonia, the deeper the color. Now, imitate the depth of color given by the distillate. In order to do so, another clean 50 c.c. Nessler tube is taken, and to it is added a certain measured volume of the diluted standard solution of ammonium chloride, and then filled with distilled water to the 50 c.c. mark and stirred thoroughly. Then 2 c.c. of Nessler reagent is added, and compared in color with the 50 c.c. of distillate, by placing the two tubes side by side on a white surface, looking through and noting which is of the deeper color. Should they be of equal depth, the Nesslerizing is accomplished. If the two solutions be not of equal depth, another standard must be made up with water, dilute standard ammonia, and Nessler reagent, and another comparison must be made.

Calculation.—The dilute standard solution of ammonium chloride contains 0.00001 gram of ammonia in 1 c.c. If it required 5 c.c. of the standard solution to imitate the color of the distillate, and since 1 c.c. contains 0.01 milligram, or 5 c.c. contain 0.05, then the 200 c.c. of water taken contain 0.05 milligram ammonia and

1,000 c.c. or 1 liter, therefore, contain 0.25. In this case, then, the free ammonia would be 0.25 parts per million.

ALBUMINOID AMMONIA.

To the water left in the Erlenmeyer flask after distilling off the 50 c.c. for free ammonia, as above, add 25 c.c. of alkaline permanganate of potash solution, and distill another 50 c.c. into a Nessler tube. Add 2 c.c. of Nessler reagent, and proceed the same as for free ammonia. The number of c.c. of standard ammonia solution it required, multiplied by 0.05, gives the parts per million of albuminoid ammonia.

OXYGEN CONSUMED IN MOIST COMBUSTION.

Measure out 100 c.c. of the water into an Erlenmeyer flask of about 8 ounce capacity. Run in from a burette 20 c.c. of the potassium permanganate solution of known strength and ½ c.c. of caustic soda solution (1:2). Boil for ten minutes, then add while hot 20 c.c. of $\frac{1}{100}$ normal solution of oxalic acid and 5 c.c. of sulphuric acid (1:4); after shaking, run in from a burette the permanganate of potash solution about ½ c.c. at a time, finally 0.1 c.c., shaking after each addition until a permanent pink color appears and remains for a minute. The number of c.c. it required times 0.8 gives the parts per million of oxygen consumed in moist combustion.

1 c.c. of the permanganate solution = 0.00008 g. oxygen.

TEMPORARY AND PERMANENT HARDNESS.

Measure out 250 c.c. of the water and pour into a glass beaker of about 400 c.c. capacity. Cover with a watch glass and boil, keeping up the volume with distilled water for about 1 hour. Filter through an ashless filter paper and wash with hot water, using a "policeman" (rubber-tipped glass rod) to remove all traces of the precipitate adhering to the sides and bottom of the beaker. Dry in a hot air bath, burn, and ignite the filter paper in a weighed platinum crucible. Heat over blast lamp until weight remains constant, cooling in desiccator. The number of milligrams, multiplied by 8, gives the approximate amount of temporary hardness in parts per million, or carbonates of lime, magnesia, iron and alumina, the latter two being very seldom found. The lime and magnesia are weighed as the oxides, and by multiplying the same by 2 we obtain approximately the corre-

sponding amount of carbonates in 250 c.c. of water, or, in milligrams per liter, by multiplying by four.

The permanent hardness is that part of the total residue which is not removed by boiling.

SUSPENDED MATTER.

If amount appears to be in excess, take a liter of the water, after shaking thoroughly, and pour it through a dried and weighed paper filter. Wash a few times with distilled water in order to remove any traces of suspended matter that may adhere to the sides of the flask. Dry at 105-110° C., in air bath, cool, and weigh.

Weight found in milligrams per liter is parts per million of suspended matter.

Ignite the weighed paper filter in a weighed platinum crucible, cool, and weigh again. Number of milligrams of ash is parts per million of inorganic matter in suspension.

Subtracting latter from total suspended matter, we obtain the organic suspended matter in parts per million.

The inorganic matter in suspension can be further examined for silica, iron, alumina and lime, by dissolving in dilute hydrochloric acid and evaporating to dryness, redissolving the residue in dilute hydrochloric acid and water. Filter and wash with hot water, ignite and weigh; the result is the amount of silica. In the filtrate, iron, alumina and lime are determined as above.

ALKALINITY.

Evaporate in a small beaker 100 c.c. of the water until about 10 c.c. remains. Filter while hot through a small paper filter into another small beaker, washing a few times with hot water. A few drops of cochineal tincture is added to the filtrate. If it is alkaline, a red or violet-red color appears. Titrate from a burette until a yellow color is produced upon the addition of decinormal sulphuric acid ($\frac{1}{10}$ c.c. at a time). The number of c.c. of decinormal sulphuric acid required multiplied by 53 gives the parts per million of alkalinity, or of carbonate of soda in the water.

NITRITES AND NITRATES.

Into two Nessler tubes measure out about 50 c.c. of the water in each. In one of these tubes place a piece of pure platinized

zinc, and to both add 1 c.c. of dilute sulphuric acid and 1 c.c. of a solution of zinc iodide and starch. Keep in a dark place for ten minutes. If no blue coloration appears, no nitrites nor nitrates are present. A blue color in the tube containing the zinc shows the presence of nitrates, blue coloring of the same depth in both tubes shows presence of nitrites, while blue color in both, but stronger in the tube containing the zinc, indicates the presence of nitrites and of nitrates.

BARLEY.

The moisture, bushel weight, glassy and half-glassy kernels, are determined in the same way as given under malt, while the yield is determined as for grits. For sulphur test see under "Hops."

GROWTH.

Steep 100 kernels of barley for 36 hours in water of room temperature. After steeping, place the kernels with their root

Sprouting Apparatus.

Grobecker's Grain Tester.

ends downward in the 100 holes of a porcelain plate constructed for the purpose. Cover the barley with a thin layer of clean sand well saturated with distilled water. The tray containing the 100 grains is kept over a dish of water at a temperature of 25-30° C. for 4 days. The grown kernels are then counted, and in a good barley should amount to 95 per cent. In the absence of the *perforated* porcelain plate the 100 kernels may be made to sprout *after steeping* between layers of well moistened filter paper. Keep

at a temperature of 25-30° C. for 4 days, taking out each day such barley kernels as have attained a full growth.

WEIGHT OF 1,000 KERNELS.

Weigh 100 kernels of barley on a weighed watch glass, using the analytical balance. The weight in grams multiplied by 0.353 equals the weight of 1,000 kernels in ounces.

MALT.

The malt is first sifted through a 20 mesh sieve in order to get rid of the rootlets and any particles of dust and dirt it may contain.

MOISTURE DETERMINATION.

Use technical balance. Weigh out about 21-22 grams of the sample, grind and weigh exactly 20 grams of the ground malt in a previously weighed glass dish. Close dish with a weighed glass cover, and dry in a hot air bath for 3 hours at a temperature of 100-105° C., removing lid while drying. Cover with lid, and after cooling in desiccator, weigh again. The weight of the dried malt + dish + cover is subtracted from the weight of the empty dish + cover + 20 grams malt, and the difference multiplied by 5 gives the percentage of moisture.

YIELD.

Use technical balance, weigh out about 51-52 grams of the sample, grind and weigh out exactly 50 grams of the ground malt. Heat 300 c.c of distilled water in a weighed copper beaker to 45° C., add malt and keep at 45° C. for half an hour. Raise temperature 5° every five minutes until 70° C. is reached; keep between 70-73° for half an hour. Conversion is complete when a drop of the mash shows no further blue or reddish color on addition of a drop of iodine solution. Cool to about 17° C., dry outside of beaker, and rinse stirring thermometer with pure water. Weigh up to 400 grams plus the weight of the empty beaker, that is, if, for instance, the weight of the dry empty beaker was 200 grams, add distilled water until the weight is exactly 600 grams. Mix thoroughly by stirring with a glass rod or thermometer, and filter into a clean, dry pint bottle. If necessary, refilter the first part of the filtrate a few times in order to obtain a clear wort. Let the wort drain, cool to 15° C., and weigh with the picnometer, or an accurate saccharometer, and thus obtain the *Balling* or extract of the wort.

CALCULATION OF THE YIELD.

The yield is calculated by substituting in the following formulas for M the per cent of moisture and for B the per cent of extract:

$$\frac{(700 + M) \times B}{100 - B} = \text{yield}; \quad \frac{\text{yield} \times 100}{100 - M} = \text{yield of malt in water-free condition.}$$

Suppose the Balling was found to be 9 per cent, and the Moisture 5.5 per cent, then by substituting in the above formulas we have:

$$\frac{(700 + 5.5) \times 9}{100 - 9} = \frac{6349.5}{91} = 69.77 \text{ yield.}$$

$$\frac{6977}{94.5} = 73.83 \text{ yield of malt in water-free condition.}$$

EXPLANATION OF FORMULAS.

Yield.—As the 50 grams of malt were weighed up to 400 grams, the proportion is 350 grams of water to 50 grams of malt, or calculating on 100, the proportion would be doubled, or 700 grams of water to 100 grams of malt. As the moisture in the malt was found to be 5.5 per cent, or 5.5 grams per 100 grams of malt, then the total water is 705.5 grams. Subtracting the Balling from 100, we obtain the amount of water in every 100 grams of wort, or 91 grams. Knowing, then, that every 100 grams of wort contains 91 grams of water and 9 grams of extract, 1 gram of water holds in solution $\frac{1}{91}$ of 9, or 0.0989 grams extract, and 705.5 grams of water hold in solution $705.5 \times 0.0989 = 69.77$ grams extract, or 100 grams malt have yielded 69.77 grams extract, i. e., yield of malt is 69.77 per cent.

Yield of Malt in Water-free Condition.—The yield, or 69.77, comes from only 94.5 grams of dry malt, the remaining 5.5 per cent being water. If, then, a yield of 69.77 per cent is obtained from 94.5 grams of dry malt, one gram of dry malt contains $\frac{1}{94.5}$ of 69.77, or 0.7383 grams extract, and 100 grams of dry malt contain 100 times as much, or 73.83 grams extract, or yield of malt in water-free condition is 73.83 per cent.

DETERMINATION OF THE GLASSY, HALF GLASSY AND MEALY KERNELS.

The simplest method of determination is by the bite, glassy kernels being hard and offering a strong resistance to crushing, while mealy kernels are soft and can be crushed very readily. Half glassy kernels are neither soft nor hard, but medium.

Grobecker's Grain Tester for the Determination of Glassy, Half Glassy and Mealy Kernels.—This is an instrument in which 50 grains of malt are cut with a sharp blade, so as to leave a smooth surface on each grain. Each half-grain is then tested for glassy, half-glassy and mealy condition, by applying a sharp knife-point and noting the resistance.

ALBUMEN.

Weigh out exactly one gram of malt and transfer in Kjeldahl flask, after adding 0.7 gram mercuric oxide and 20 c.c. of chemically pure sulphuric acid; proceed as in the determination of albumen in beer, using the factor 0.875 in place of 0.035 to obtain the percentage of albuminoids in malt.

Explanation of the factor 0.875.—One c.c. decinormal sodium hydrate solution = 0.0014 g. nitrogen. The nitrogen, when multiplied by the factor 6.25, gives the albumen, or,

$0.0014 \times 6.25 = 0.00875$ in one gram (as one gram of malt was taken), or 0.875 in 100 grams.

GROWTH.

100 kernels are counted out and sorted in five groups, according to the length to which the acrospire has grown. The lengths are $0 — \frac{1}{4}$, $\frac{1}{4} — \frac{1}{2}$, $\frac{1}{2} — \frac{3}{4}$, $\frac{3}{4} — 1$, and over one or overgrown. To obtain the length of the acrospire, the husk of the malt is peeled off with a knife point, on the round side of the grain, beginning at the root end. The length of the acrospire is then compared with the entire length of the grain, and placed in one of the five groups. In a good sample the acrospire should have attained the length of $\frac{3}{4} — 1$, in at least 75 per cent of the kernels.

BUSHEL WEIGHT.

The apparatus used for this purpose consists of a brass cup and a graduated beam, and is known as a "balance" or "grain tester." The cup is filled with the sifted malt, or barley, and struck off, and the beam so graduated that by balancing the cup it will designate exactly the bushel weight, or how many pounds it will weigh to the bushel.

Sinkers.—100 grains of malt are placed into a glass beaker containing water at ordinary temperature. Barley grains, or partially malted grains will sink to the bottom, and by counting the same, the percentage of sinkers will be obtained. It should not exceed 15 per cent in a good sample.

DIASTATIC POWER OF MALT.

Lintner's Method.—A soluble starch solution is prepared by covering potato starch with 7.5 per cent hydrochloric acid, allowing to stand for seven days at ordinary temperature, and for three days at 40° C., whereby it loses its property of forming a paste. The starch is then repeatedly washed with cold water (by decantation) until it shows no reaction with blue litmus paper. The water is now poured off and the starch dried in the air. This product gives a clear solution in water. Two grams of the soluble starch is dissolved in 100 c.c. of water, and a solution of malt extract prepared by adding to 25 grams of finely ground malt distilled water to 500 c.c. This solution is allowed to stand for six hours at ordinary temperature (about 20° C.). Filter and dilute the clear filtrate with an equal volume of distilled water. In ten test tubes, each of which contains 10 c.c. of the 2 per cent soluble starch solution, there is added 0.1, 0.2, 0.3, etc. up to 1 c.c. of the malt extract. Mix thoroughly, and allow to stand for one hour at ordinary temperature (20° C.). Five c.c. of Fehling solution is then added to each of the ten test tubes and then all are placed in boiling water for ten minutes. The test tube in which all of the copper has been reduced is determined by filtering and testing the filtrate by means of doubled filter paper that has been previously moistened with a dilute solution of acetic acid and potassium ferrocyanide (see Volumetric Estimation of Sugar in Wort). If no red coloration is produced on the under side of the filter paper, the copper is completely reduced. If this was found to require between 0.3 c.c. and 0.4 c.c, and a more accurate result is desired, then 10 c.c. of the original solution of malt extract is diluted up to 100 c.c. The test is now repeated, using 3.1 c.c., 3.2 c.c., 3.3 c.c., etc., up to 4 c.c. Supposing it was now found to require 3.8 c.c., then, as the diastatic power is equal to 100 when 0.1 c.c. of the original solution of malt extract prepared in the above manner, or 0.2 c.c. of the diluted solution of malt extract completely reduces the

5 c.c. of Fehling solution, 3.8 c.c. or 0.38 c.c. of original solution will be equal to a diastatic power of

$$\frac{100}{3.8} \times 2 = 52.6.$$

CORN PRODUCTS AND RICE.

OIL.

Grind finely ten grams of the sample. Then place in extraction tube of a continuous extractor, and extract with 30 c.c. of ether for three hours, allowing it to collect in a flask previously weighed on the analytical balance. After three hours' extraction distill off the ether, by allowing the flask to remain in warm water until the odor of ether is no longer detected. Keep in hot air bath (90° C.) for one hour; cool in desiccator, and weigh. The increase in weight in grams, multiplied by ten, gives the per cent of oil.

MOISTURE.

Determined in the same way as for malt, grinding being unnecessary.

YIELD.

When mashed with 60 per cent of malt, 20 grams of the well-ground sample are placed in a weighed copper beaker, and 300 c.c. of water added. Allow to boil for half an hour, adding, if necessary, a small amount of water from time to time in order to prevent the mash getting too thick. Cool to 45° C., and add 30 grams of ground malt, the yield of which has been previously ascertained. Proceed now as for a pure malt mash.

Calculation.—(B represents Balling of wort.)

$$\frac{700 + \text{moisture in } 60\% \text{ malt and } 40\% \text{ cereal} \times B}{100 - B} = \text{total yield},$$

or,

Yield of 60 per cent malt and 40 per cent grits.

Find yield of 60 grams of malt; subtract this malt yield from total yield, and obtain yield of 40 grams of grits. Then by multiplying by 100 and dividing by 40, the yield of the grits is obtained.

$$\frac{(\text{Total yield} - \text{yield of } 60 \text{ malt}) \times 100}{40} = \text{yield of cereal}.$$

ASH.

Three grams of the ground sample are weighed out in a platinum or porcelain dish, and ignited until ash is white or the weight is constant. The weight of the ash multiplied by 100 and divided by 3 is the percentage of ash.

CORN FLAKES.

Analysis the same as corn products and rice, except that in the determination of the yield it is mashed directly at 67° C.

BREWING SUGARS.

EXTRACT AND MOISTURE.

Dissolve twenty grams of the sample in about 100 c.c. of distilled water, heat if necessary, until all is dissolved, cool and weigh up to 200 grams with distilled water. After mixing thoroughly, take the specific gravity at 15° C. by means of the picnometer, and refer the same to Balling's extract tables. The corresponding amount of extract thus obtained, multiplied by ten, gives the percentage of extract. The extract minus 100 = per cent moisture.

COLORANTS.

EXTRACT AND MOISTURE.

Twenty grams of the color is weighed up to 200 grams with distilled water. After mixing thoroughly take the specific gravity, and multiply the corresponding per cent Balling by 10, which will give the extract in 100 grams. The extract minus 100 = moisture.

SUGAR.

Measure out 25 c.c. of the above sugar color solution into a 250 c.c. flask, and dilute to the mark with distilled water. After mixing thoroughly by shaking, run 25 c.c. into a previously prepared boiling Fehling solution. After adding, let the copper solution come to a boil and allow to boil two minutes for sugar colors, and four minutes in case of a malt color. Filter while hot, and continue as under the determination of dextrose in grape-sugar. Refer the amount of copper to F. Allihn's dextrose table. The amount of dextrose thus obtained is multiplied by 400 and divided by the specific gravity of the first solution, and the result will be the percentage of dextrose in the coloring. For

a malt color multiply the amount of copper by 353.98, and divide by the specific gravity of the first solution to obtain the percentage of maltose.

ALBUMEN.

Determined in a ten per cent solution as given under Beer.

COLOR STRENGTH.

Measure out 25 c.c. of the solution in which the extract was determined, into a 500 c.c. flask, and dilute up to the mark with distilled water. After mixing thoroughly, dilute 25 c.c. of this solution to 100 c.c. and transfer into a clear white four-ounce bottle (flat). Into a bottle of exactly the same size and shape, add 100 c.c. of distilled water. Now add from a graduated burette 1-10 standard iodine solution, 1-10 of a c.c. at a time until the same depth of color has been reached. The number of c.c. of 1-10 standard solution required, multiplied by the dilution, represents the color strength. In this case the sugar color was diluted 800 times.

HOPS.

PHYSICAL APPEARANCE.

Note the general color of the hops and if they have been cleanly picked; size and condition of cones, number and size of seeds, color and amount of lupulin, condition of lupulin as to taste, and aroma. Note if the lupulin is greasy or sticky.

SULPHUR.

Soak for half an hour twenty grams of hops in 250 c.c. of distilled water. Meanwhile prepare a generator for hydrogen gas. Place in an Erlenmeyer flask of about 150 c.c. capacity a piece of zinc (five grams) free from sulphur and 20 c.c. of c. p. dilute hydrochloric acid. Stopper loosely with a cork, holding a strip of filter paper on the under side. Moisten the filter paper with a dilute solution of sugar of lead (acetate of lead). If the strip remains white after the apparatus has been run for half an hour, the zinc and acid are pure. Now run in some of the water which has extracted the hops for half an hour. If the strip of filter paper is colored brownish to black in five minutes "much sulphur" is present in the hops; "medium" if the color appears in ten minutes, "little sulphur" if the color appears in fifteen minutes and a "slight trace" if it appears in twenty minutes.

MINERAL OIL.

SPECIFIC GRAVITY.

Into a 100 c.c. flask that has been previously tested and weighe(fill the oil at 15° C. to mark, and weigh. The weight of flask plu oil, minus the weight of the empty flask, divided by 100, equals th specific gravity, which can be converted into degrees Beaume b referring to table.

FLASH POINT.

Fill about ¾ full a small porcelain crucible of about 25-50 c.c. ca pacity. Suspend a 360° Centigrade thermometer in the oil, s that the thermometer bulb does not come in contact with the bot tom of the crucible. Heat gradually (about 10° a minute) ove a small Bunsen flame, testing every 5° for fumes by passing lighted match over the surface of the oil and noting the lowe temperature when a flash appears.

FATTY ACIDS.

Into a test tube, containing a small piece of caustic soda, ad about 5 c.c. of oil. Boil carefully for a few minutes over a direc flame and allow to stand for a few minutes. If the oil become solid it indicates the presence of fatty acids.

MINERAL ACIDS.

Shake thoroughly a small quantity of the oil with distilled wate Titrate with decinormal caustic soda solution, using cochineal a an indicator. In case the color changes to violet red after th addition of 0.1 or 0.2 c.c., the oil may be considered as free fron mineral acids.

CHEMICALS, STANDARD SOLUTIONS AND REAGENTS

Chemicals necessary to make the different standard solution and reagents.

Acid, acetic, glacial	1 lb.
Acid, hydrochloric, C. P.	1 lb.
Acid, nitric, C. P.	1 lb.
Acid, oxalic, C. P.	4 oz.
Acid, sulphuric, C. P.	1 lb.
Acid, tannic, pure	4 oz.
Ammonium acetate, C. P.	4 oz.
Ammonium hydrate, C. P.	4 lbs.
Ammonium carbonate, C. P.	4 lbs
Ammonium chloride, C. P.	½ lb.

Ammonium oxalate, C. P.	4 oz.
Alcohol, ethyl, 95%	1 qt.
Barium chloride, C. P.	½ lb.
Cochineal	4 oz.
Copper sulphate, C. P.	2 lbs.
Ether, sulphuric	2 lbs.
Iodine, resublimed	1 oz.
Iron chloride, C. P.	1 oz.
Lead acetate, C. P.	4 oz.
Litmus paper, red and blue.	
Magnesium chloride, C. P.	½ lb.
Mercury bichloride, C. P.	4 oz.
Mercuric oxide	4 oz.
Potassium chromate, C. P.	1 oz.
Potassium ferrocyanide, C. P.	1 oz.
Potassium hydrate (in sticks), C. P.	1 lb.
Potassium iodide, C. P.	4 oz.
Potassium permanganate, C. P.	4 oz.
Potassium sulphide, C. P.	4 oz.
Rochelle salt, C. P.	2 lbs.
Silver nitrate, C. P.	1 oz.
Sodium carbonate, C. P.	4 oz.
Sodium chloride, C. P.	2 oz.
Sodium acetate, C. P.	4 oz.
Sodium hydrate, pure	2 lbs.
Sodium phosphate	4 oz.
Uranium, acetate	1 oz.
Zinc, granulated	½ lb.
Zinc, in sticks	½ lb.
Zinc chloride	1 oz.
Zinc iodide	1 oz.

Decinormal Sulphuric Acid.—Dilute 3.5 c.c. concentrated chemically pure sulphuric acid up to 1 liter with distilled water. Mix thoroughly by shaking. The sulphuric acid is then determined in the following manner:

Run 25 c.c. of the solution by means of a burette into a glass beaker of about 100 c.c. capacity, add about 25 c.c. distilled water and a few drops of hydrochloric acid. Cover beaker with a watch glass and heat to boiling, add 5 to 10 c.c. barium chloride solution, which will precipitate the sulphuric acid as a white precipitate o

barium sulphate. Allow to settle at a gentle heat or by placing o a boiling water bath until solution becomes clear. In order to in sure a complete precipitation of the sulphuric acid, a few drops o barium chloride solution are again added. If no further precipi tate is produced, filter off the clear liquid while hot, through a ashless paper filter. The remaining barium sulphate is nov washed with boiling water and transferred to the filter. In orde to wash out all the precipitate contained in the beaker with boilin water, a glass rod with a small piece of rubber tubing attached t its end is employed, commonly called a "policeman." Th precipitate on the filter is now washed with boiling water until few drops of the filtrate, when collected in a test tube, produces n turbidity upon the addition of a few drops of silver nitrate solu tion. Place the filter in a drying oven of about 100° C until dry. Ignite in a weighed porcelain or platinum crucible unti it assumes a white appearance. The crucible is then allowed t cool in a desiccator and weighed again. As this is a decinorma solution, the precipitate of barium sulphate should weigh 0.29 grams, or 0.291 grams plus the weight of the empty crucible i order to be correct. Supposing, however, that the weight wa found to be 0.339 grams instead of 0.291 grams, then dilute ac cording to the following proportion:

$$0.291 : 0.339 = x : 1000$$
$$x = 858$$

that is, 858 c.c. of the solution should be diluted up to 1000 c.c in order to be a decinormal sulphuric acid solution; 25 c.c. of this must contain exactly 0.291 gram of barium sulphate when precipitated with barium chloride in the manner just described, which should always be carefully done a second time, to insure accurate results. This solution should be kept in a well-stoppered glass bottle.

Decinormal Caustic Soda Solution.—Dissolve 4.5 to 5 grams of pure dry caustic soda in distilled water, and make up to one liter. Mix the solution thoroughly by shaking and measure out 25 c.c. by means of a burette into a dry glass beaker of about 100 c.c. capacity. Add a few drops of cochineal tincture; the solution will change to a violet red color. Now run in decinormal solution of sulphuric acid slowly, by means of a burette, into the caustic soda solution, stopping at the neutral point, or the point at which the color of the solution changes from violet red to light yello

Read off the number of cubic centimeters of acid it required to reach the neutral point. Suppose it required 30 c.c., then 25 parts even of caustic soda solution must be diluted to 30 parts by volume. In case we have 950 c.c. of the solution on hand, then it would have to be diluted to $\frac{30}{25}$ of 950, or 1140 c.c., and 25 c.c. of this solution well mixed should neutralize exactly 25 c.c. of the decinormal sulphuric acid solution.

Standard Ammonium Chloride Solution Used for Ammonia Determination.—Dissolve 3.15 grams pure ammonium chloride in distilled water, and dilute to one liter, mixing well. Then take 10 c.c. of this solution and dilute it to one liter with distilled water. Shake well. Each c.c. of this solution contains 0.01 of a milligram of ammonia or 0.00001 gram of ammonia.

Solution of Alkaline Permanganate Used for Albuminoid Ammonia Determination.—Two hundred grams of pure caustic potash and eight grams of pure potassium permanganate are dissolved in one liter of distilled water, allowed to boil for fifteen minutes in a large porcelain dish, cooled and made up to one liter with distilled water. Transfer into well-stoppered bottle.

Nessler's Reagent Used for Ammonia Determination.—In making this reagent 8.5 grams of corrosive sublimate (mercuric chloride) is dissolved in about 150 c.c. of boiling water, 17.5 grams of potassium iodide is dissolved in 50 c.c. of cold water, and the corrosive sublimate solution slowly added to the iodide solution under constant stirring until a red precipitate is formed that remains after stirring. Now, add a solution of 60 grams of caustic potash in 100 c.c. of water, and dilute almost to one liter in a liter flask. Then add some of the original corrosive sublimate solution until a slight red precipitate again appears and remains. Fill up to one liter with distilled water, and after letting the precipitate settle, pour the clear liquid off into a brown glass bottle and it is ready for use.

Acid Solution of Acetate of Sodium.—Used in determining phosphoric acid, volumetrically. One hundred grams C. P. acetate of sodium and 100 c.c. concentrated acetic acid are made up to one liter with distilled water.

Concentrated C. P. Sulphuric Acid—Sp. g. 1.84—Should be free from ammonia and always well stoppered.

Dilute Sulphuric Acid of Reagent Strength.—Run one part by *volume of the* chemically pure concentrated sulphuric acid into *three volumes of* distilled water.

In diluting concentrated acids always pour the acid slowly into the water, never the water into the acid.

Dilute Hydrochloric Acid of Reagent Strength.—One volume of the C. P. concentrated acid is poured into three volumes of distilled water.

Hydrochloric Acid of 1.125 Specific Gravity.—To every 100 c.c of C. P. hydrochloric acid (Sp. Gr. 1.2) add 62.5 c.c. of water The specific gravity should then be taken by means of the picnometer at 15° C.

Dilute Nitric Acid.—One volume of concentrated C. P. nitric acid to three volumes of distilled water.

Zinc Iodide and Starch Solution.—Mix four grams of starch powder in a glass beaker with a little water, and slowly pour the resulting milky liquid under constant stirring into a boiling solution of twenty grams pure chloride of zinc in 100 c.c. of water Continue boiling until the solution becomes somewhat clear, then add two grams of pure zinc iodide dissolved in distilled water dilute to one liter, and filter. The clear solution is kept in a well stoppered bottle. It should give no blue color in ten minutes when 0.2 c.c. of it is diluted to 50 c.c. and acidified with 2 c.c. reagent sulphuric acid (1:4).

Fehling Solution.—Blue Solution. 69.27 grams of pure recrystallized copper sulphate is dissolved in water and diluted to one liter.

White Solution.—346 grams Rochelle salt (sodium potassium tartrate), and 100 grams sodium hydrate (caustic soda), are dissolved in water and diluted to one liter. Filter through glass wool.

A mixture of equal portions of these two solutions is called the Fehling Solution.

Gravimetrically 30 c.c. of each and 60 c.c. of water is used Volumetrically 10 c.c. of each and 20 c.c. of water is used.

Cochineal Tincture.—Six grams of powdered cochineal is extracted in half a liter of dilute alcohol (200 c.c. 95 per cent ethylic alcohol diluted to 500 c.c. with distilled water). Allow to stand for a few hours at room temperature, and filter. Keep in well stoppered bottle.

Standard Uranium Acetate Solution.—Dissolve 33 to 34 grams of uranium acetate in about 200 c.c. distilled water, add 5 c.c. of glacial acetic acid, dilute to one liter with distilled water. F

low to stand for a few days in a dark place, and filter. A solution of phosphoric acid, of known strength, is made by dissolving 10.085 grams of crystallized C. P. sodium phosphate in distilled water to one liter (50 c.c. of this solution contain 0.1 gram P_2O_5). When 50 c.c. of this solution is evaporated to dryness in a weighed platinum dish and ignited over a Bunsen burner, finally over a blast lamp, after cooling in desiccator it should weigh 0.1874 grams. To test the standard uranium acetate solution, take 50 c.c. of the sodium phosphate solution, acidify with 5 c.c. of acid acetate of soda solution and heat to about 90° C. Now run in from a burette the standard uranium acetate, first 5 c.c., then ½ c.c. at a time, testing after each addition, until a drop, when added to a few small crystals of potassium ferrocyanide, gives a reddish brown reaction. One c.c. of standard uranium acetate solution should equal 0.005 gr. P_2O_5, or the 50 c.c. of the sodium phosphate solution should require 20 c.c. of the standard uranium solution to precipitate all of the P_2O_5. Supposing it took 19 c.c. and we have on hand 980 c.c. of the standard solution; then

$$19:20 = 980:x.$$

i. e., the solution should be made up to 1031.6 c.c., or 51.6 c.c. of distilled water is added to the 980 c.c. of the solution on hand.

Standard Solution of Silver Nitrate.—Weigh 18 grams of C. P. silver nitrate, and dilute to 1 liter with distilled water. A testing solution is now prepared in the following manner: Ignite moderately about 4 grams of C. P. powdered chloride of sodium, cool, and transfer into a clean and dry test tube that can be well closed. Place in a drying oven at a temperature of 100 to 105° C. for about half an hour, cool in desiccator, and weigh. Carefully shake out a small quantity (about 0.1 gram) into a dry beaker, close quickly, and weigh again. The difference in weight represents the exact amount of salt taken. Now dissolve in about 50 c.c. of distilled water and add a few drops of potassium chromate solution. Run in slowly from a burette the silver nitrate solution, constantly stirring the testing solution until a slight red coloration remains. The number of c.c. used, multiplied by 0.00585 should be equal to the quantity weighed out. Supposing it required 16.5 c.c. to precipitate the chlorine in 100 milligrams of salt, then the solution must be diluted according to the following proportion:

$$100:5.85 = 16.5:x,$$
$$x = 965,$$

i. e., if 965 c.c. of the decinormal solution is diluted to 1000 c.c. then it would require 5.85 grams of salt, or 1 c.c. of the decinormal nitrate of silver solution corresponds to 0.00585 g. NaCl, or 0.00355 g. Cl.

Ammonia Fluid.—1 part of ammonia water specific gravity 0.98 and 2 parts of water.

Sodium Phosphate Solution.—For precipitating magnesia. One part of C. P. sodium phosphate in 10 parts of distilled water.

Ammonium Carbonate Solution.—1 part of C. P. ammonium carbonate in 4 parts water; add 1 part ammonia fluid.

Ammonium Chloride Solution.—To keep the magnesia in solution when precipitating lime. One part C. P. chloride of ammonia in 8 parts water.

Ammonium Oxalate Solution.—1 part C. P. ammonium oxalate in 25 parts water.

Barium Chloride Solution.—For precipitating sulphates. One part C. P. barium chloride in 10 parts of water.

Lead Acetate Solution.—For sulphur test. Concentrated solution.

Silver Nitrate Solution.—For qualitative tests. One part of silver nitrate in fifty parts of water.

Potassium Ferrocyanide Solution.—For volumetric estimation of sugar. One part in twelve parts of water.

Potassium Chromate Solution.—For chlorine titration. Dissolve one part of C. P. potassium chromate in ten parts of water.

Potassium Sulphide Solution.—For albumen determination: Dissolve 40 grams of potassium sulphide in one liter of distilled water.

Acetic Acid Solution.—For volumetric estimation of sugar. One part glacial acetic acid in ten parts of water.

Chloride of Iron Solution.—For qualitative test. One part in ten parts of water.

Decinormal Iodine Solution.—Dissolve 12.7 grams of iodine and twenty-five grams of potassium iodide in distilled water, and dilute to one liter.

Oxalic Acid Solution $\frac{1}{100}$ Normal.—Dissolve 0.63 grams oxalic acid C. P. in distilled water and dilute to one liter.

Permanganate of Potash Solution $\frac{1}{100}$ Normal.—Dissolve 0.34 grams permanganate of potash in distilled water and dilute to one liter.

In order to test the above two solutions, take 20 c.c. of the oxalic acid solution, add 5 c.c. sulphuric acid (1:4), and heat to boiling. Run in slowly from a burette the permanganate of potash solution until it assumes a distinct reddish tinge. The solution, in order to be correct, should require 20 c.c. Suppose, however, it required 19.8 c.c., and we have 950 c.c. of the solution left, then dilute in the following proportion:

$$19.8:20 = 950:x,$$
$$x = 959.5,$$

i. e., add 9.5 c.c. of distilled water to the permanganate of potash solution.

LIST OF APPARATUS.

Air Bath (copper) and Support; not smaller than 8x10; used for drying purposes.

Aspirator Bottle, one gallon, for distilled water; tubulated on foot.

Analytical Balance, short beam, with rider attachment, sensitive to one milligram; and a set of weights from fifty grams down to one milligram.

Technical Balance, capacity one kilogram; set of weights from one kilogram down to one centigram.

One Platinum dish of 100 c.c. capacity.

One platinum crucible 10 c.c. capacity.

Bohemian Glass Beakers—Griffins, low, wide-shape, with lip; capacity 150 c.c., 200 and 300 c.c. about half a dozen of each.

Bellows—Foot Blower. Blast Lamp for gas and air.

Reagent Bottles, one pint, about one dozen; narrow mouth.

Small Glass Stoppered Reagent Bottles, with chemical names distinctly blown in glass.

Glass Tubing, assorted.

Glass Rods, assorted.

Graduates—one 120 c.c., and one 250 c.c.

Test Tube Brushes, half a dozen.

Camel Hair Brushes, several.

Five 50 c.c. Burettes, graduated in $\frac{1}{10}$ c.c.

Bunsen Burners, about half a dozen.

Iron Stands, with clamps, universal; two.

Clamps (Hofmann's), several.

Clamps *(Mohr's)*, several.

Glass Condensers, about 12 inches long; three or four.

Iron Wire Gauze, for covering tripods.

Cork Borers, one set.
Corks and Rubber Stoppers, assorted.
Small Porcelain Crucibles, height, 1¼ inches; width, 1¾ inche[s]; half a dozen.
Crucible Tongue, double bent; one.
Saccharometer Cylinders.
Balling Saccharometer, 0 to 20 per cent.
Balling Saccharometer, 6 to 7 inches long, 0 to 10 per cent.
Picnometer, 50 c.c.
Nessler Cylinders, 50 c.c. capacity; two.
Desiccator, one.
Porcelain Evaporating Dishes, 4½ inches; half a dozen.
Porcelain Evaporating Dish, one large, 10 inches.
Fat Extraction Apparatus; one.
Munktell's Swedish Filter Paper No. 0; 100 7 c. m. and 1[0] 9 c. m.
Filter Paper in Sheets, ¼ ream, 20x20.
Erlenmeyer Flasks, ½ dozen 8-oz. and ½ dozen 16-oz.
Measuring Flasks:
- 1 liter flask.
- ½ liter flask.
- 2—250 c.c. flasks.
- 1—200 c.c. flask.
- 2—100 c.c. flasks.

Funnels:
- 2—5-in.
- 2—2½-in.
- 2—2-in.

Mortars with Pestles:
- Wedgewood, 5-in.
- Agate, 3-in.
- Iron, 6-in.

Pipettes:
- 1—50 c.c.
- 2—25 c.c.
- 1—20 c.c.
- 1—10 c.c.
- 1— 5 c.c.
- 1— 2 c.c.

Rubber Tubing, assorted.
Spatula, steel, 4 or 5 inches; one.
[Bu]rette Stand; one.

Test Tube Stand; one.
Filter Stand; one.
Test Tubes, 4 and 5 inches in length; one dozen.
Kjeldahl Flasks, pear-shaped, long neck; one dozen.
100° Centigrade Thermometers; three.
360° Centigrade Thermometer; one.
Clay Triangles; half a dozen.
Tripods; half a dozen.
Water Bath, 8-inch; one.
Watch Glasses, assorted; half a dozen.
Copper Beakers, half-liter capacity; three.
Separatory Funnel; one.
Sand Baths; half a dozen.
Wash bottle, capacity about 500 c.c.
One Drying Dish, with ground lid.

BAUMHAUER'S ALCOHOL TABLE, CALCULATED AT 15° C.
(By Dr. Georg Holzner.)

Specific Gravity.	Per Cent. By Weight.	Specific Gravity.	Per Cent. By Weight.	Specific Gravity.	Per Cent. By Weight.
0.9981	1.01	0.9944	3.08	0.9907	5.31
0.9980	1.06	0.9943	3.14	0.9906	5.37
0.9979	1.12	0.9942	3.20	0.9905	5.44
0.9978	1.17	0.9941	3.26	0.9904	5.50
0.9977	1.22	0.9940	3.31	0.9903	5.56
0.9976	1.28	0.9939	3.37	0.9902	5.62
0.9975	1.33	0.9938	3.43	0.9901	5.69
0.9974	1.38	0.9937	3.49	0.9900	5.75
0.9973	1.44	0.9936	3.54	0.9899	5.82
0.9972	1.49	0.9935	3.60	0.9898	5.89
0.9971	1.54	0.9934	3.66	0.9897	5.95
0.9970	1.60	0.9933	3.72	0.9896	6.02
0.9969	1.65	0.9932	3.77	0.9895	6.09
0.9968	1.71	0.9931	3.83	0.9894	6.16
0.9967	1.77	0.9930	3.89	0.9893	6.22
0.9966	1.82	0.9929	3.95	0.9892	6.29
0.9965	1.88	0.9928	4.01	0.9891	6.36
0.9964	1.94	0.9927	4.07	0.9890	6.43
0.9963	2.00	0.9926	4.13	0.9889	6.50
0.9962	2.05	0.9925	4.19	0.9888	6.56
0.9961	2.11	0.9924	4.25	0.9887	6.63
0.9960	2.17	0.9923	4.31	0.9886	6.70
0.9959	2.22	0.9922	4.37	0.9885	6.77
0.9958	2.28	0.9921	4.44	0.9884	6.84
0.9957	2.34	0.9920	4.50	0.9883	6.90
0.9956	2.40	0.9919	4.56	0.9882	6.97
0.9955	2.45	0.9918	4.62	0.9881	7.04
0.9954	2.51	0.9917	4.68	0.9880	7.11
0.9953	2.57	0.9916	4.75	0.9879	7.17
0.9952	2.62	0.9915	4.81	0.9878	7.24
0.9951	2.68	0.9914	4.87	0.9877	7.31
0.9950	2.74	0.9913	4.93	0.9876	7.38
0.9949	2.80	0.9912	5.00	0.9875	7.45
0.9948	2.85	0.9911	5.06	0.9874	7.52
0.9947	2.91	0.9910	5.12	0.9873	7.58
0.9946	2.97	0.9909	5.18	0.9872	7.6[illegible]
0.9945	3.03	0.9908	5.25	0.9871	[illegible]

BALLING'S EXTRACT TABLE.

Specific Gravity.	Per Cent Balling.	Specific Gravity.	Per Cent Balling.	Specific Gravity.	Per Cent Balling.	Specific Gravity.	Per Cent Balling.
1.0000	0.000	1.0067	1.675	1.0134	3.350	1.0201	5.025
1.0001	0.025	1.0068	1.700	1.0135	3.375	1.0202	5.050
1.0002	0.050	1.0069	1.725	1.0136	3.400	1.0203	5.075
1.0003	0.075	1.0070	1.750	1.0137	3.425	1.0204	5.100
1.0004	0.100	1.0071	1.775	1.0138	3.450	1.0205	5.125
1.0005	0.125	1.0072	1.800	1.0139	3.475	1.0206	5.150
1.0006	0.150	1.0073	1.825	1.0140	3.500	1.0207	5.175
1.0007	0.175	1.0074	1.850	1.0141	3.525	1.0208	5.200
1.0008	0.200	1.0075	1.875	1.0142	3.550	1.0209	5.225
1.0009	0.225	1.0076	1.900	1.0143	3.575	1.0210	5.250
1.0010	0.250	1.0077	1.925	1.0144	3.600	1.0211	5.275
1.0011	0.275	1.0078	1.950	1.0145	3.625	1.0212	5.300
1.0012	0.300	1.0079	1.975	1.0146	3.650	1.0213	5.325
1.0013	0.325	1.0080	2.000	1.0147	3.675	1.0214	5.350
1.0014	0.350	1.0081	2.025	1.0148	3.700	1.0215	5.375
1.0015	0.375	1.0082	2.050	1.0149	3.725	1.0216	5.400
1.0016	0.400	1.0083	2.075	1.0150	3.750	1.0217	5.425
1.0017	0.425	1.0084	2.100	1.0151	3.775	1.0218	5.450
1.0018	0.450	1.0085	2.125	1.0152	3.800	1.0219	5.475
1.0019	0.475	1.0086	2.150	1.0153	3.825	1.0220	5.500
1.0020	0.500	1.0087	2.175	1.0154	3.850	1.0221	5.525
1.0021	0.525	1.0088	2.200	1.0155	3.875	1.0222	5.550
1.0022	0.550	1.0089	2.225	1.0156	3.900	1.0223	5.575
1.0023	0.575	1.0090	2.250	1.0157	3.925	1.0224	5.600
1.0024	0.600	1.0091	2.275	1.0158	3.950	1.0225	5.625
1.0025	0.625	1.0092	2.300	1.0159	3.975	1.0226	5.650
1.0026	0.650	1.0093	2.325	1.0160	4.000	1.0227	5.675
1.0027	0.675	1.0094	2.350	1.0161	4.025	1.0228	5.700
1.0028	0.700	1.0095	2.375	1.0162	4.050	1.0229	5.725
1.0029	0.725	1.0096	2.400	1.0163	4.075	1.0230	5.750
1.0030	0.750	1.0097	2.425	1.0164	4.100	1.0231	5.775
1.0031	0.775	1.0098	2.450	1.0165	4.125	1.0232	5.800
1.0032	0.800	1.0099	2.475	1.0166	4.150	1.0233	5.825
1.0033	0.825	1.0100	2.500	1.0167	4.175	1.0234	5.850
1.0034	0.850	1.0101	2.525	1.0168	4.200	1.0235	5.875
1.0035	0.875	1.0102	2.550	1.0169	4.225	1.0236	5.900
1.0036	0.900	1.0103	2.575	1.0170	4.250	1.0237	5.925
1.0037	0.925	1.0104	2.600	1.0171	4.275	1.0238	5.950
1.0038	0.950	1.0105	2.625	1.0172	4.300	1.0239	5.975
1.0039	0.975	1.0106	2.650	1.0173	4.325	1.0240	6.000
1.0040	1.000	1.0107	2.675	1.0174	4.350	1.0241	6.024
1.0041	1.025	1.0108	2.700	1.0175	4.375	1.0242	6.048
1.0042	1.050	1.0109	2.725	1.0176	4.400	1.0243	6.072
1.0043	1.075	1.0110	2.750	1.0177	4.425	1.0244	6.096
1.0044	1.100	1.0111	2.775	1.0178	4.450	1.0245	6.122
1.0045	1.125	1.0112	2.800	1.0179	4.475	1.0246	6.146
1.0046	1.150	1.0113	2.825	1.0180	4.500	1.0247	6.170
1.0047	1.175	1.0114	2.850	1.0181	4.525	1.0248	6.195
1.0048	1.200	1.0115	2.875	1.0182	4.550	1.0249	6.219
1.0049	1.225	1.0116	2.900	1.0183	4.575	1.0250	6.244
1.0050	1.250	1.0117	2.925	1.0184	4.600	1.0251	6.268
1.0051	1.275	1.0118	2.950	1.0185	4.625	1.0252	6.292
1.0052	1.300	1.0119	2.975	1.0186	4.650	1.0253	6.316
1.0053	1.325	1.0120	3.000	1.0187	4.675	1.0254	6.341
1.0054	1.350	1.0121	3.025	1.0188	4.700	1.0255	6.365
1.0055	1.375	1.0122	3.050	1.0189	4.725	1.0256	6.389
1.0056	1.400	1.0123	3.075	1.0190	4.750	1.0257	6.413
1.0057	1.425	1.0124	3.100	1.0191	4.775	1.0258	6.438
1.0058	1.450	1.0125	3.125	1.0192	4.800	1.0259	6.463
1.0059	1.475	1.0126	3.150	1.0193	4.825	1.0260	6.488
1.0060	1.500	1.0127	3.175	1.0194	4.850	1.0261	6.512
1.0061	1.525	1.0128	3.200	1.0195	4.875	1.0262	6.536
1.0062	1.550	1.0129	3.225	1.0196	4.900	[illegible]	[illegible]
1.0063	1.575	1.0130	3.250	1.0197	4.925	[illegible]	[illegible]
1.0064	1.600	1.0131	3.275	1.0198	4.950	[illegible]	[illegible]
1.0065	1.625	1.0132	3.300	1.0199	4.975	[illegible]	[illegible]
1.0066	1.650	1.0133	3.325	1.0200	5.000	[illegible]	[illegible]

BALLING'S EXTRACT TABLE—Continued.

Specific Gravity.	Per Cent Balling.	Specific Gravity.	Per Cent Balling.	Specific Gravity.	Per Cent Balling.	Specific Gravity.	Per Cent Balling.
1.0268	6.681	1.0335	8.316	1.0402	9.950	1.0469	11.547
1.0269	6.706	1.0336	8.341	1.0403	9.975	1.0470	11.571
1.0270	6.731	1.0337	8.355	1.0404	10.000	1.0471	11.595
1.0271	6.756	1.0338	8.389	1.0405	10.023	1.0472	11.619
1.0272	6.780	1.0339	8.413	1.0406	10.047	1.0473	11.642
1.0273	6.804	1.0340	8.438	1.0407	10.071	1.0474	11.666
1.0274	6.828	1.0341	8.463	1.0408	10.095	1.0475	11.690
1.0275	6.853	1.0342	8.488	1.0409	10.119	1.0476	11.714
1.0276	6.877	1.0343	8.512	1.0410	10.142	1.0477	11.738
1.0277	6.901	1.0344	8.536	1.0411	10.166	1.0478	11.761
1.0278	6.925	1.0345	8.560	1.0412	10.190	1.0479	11.785
1.0279	6.950	1.0346	8.584	1.0413	10.214	1.0480	11.809
1.0280	6.975	1.0347	8.609	1.0414	10.238	1.0481	11.833
1.0281	7.000	1.0348	8.633	1.0415	10.261	1.0482	11.857
1.0282	7.024	1.0349	8.657	1.0416	10.285	1.0483	11.881
1.0283	7.048	1.0350	8.681	1.0417	10.309	1.0484	11.904
1.0284	7.073	1.0351	8.706	1.0418	10.333	1.0485	11.928
1.0285	7.097	1.0352	8.731	1.0419	10.357	1.0486	11.952
1.0286	7.122	1.0353	8.756	1.0420	10.381	1.0487	11.976
1.0287	7.146	1.0354	8.786	1.0421	10.404	1.0488	12.000
1.0288	7.170	1.0355	8.804	1.0422	10.428	1.0489	12.023
1.0289	7.195	1.0356	8.828	1.0423	10.452	1.0490	12.047
1.0290	7.219	1.0357	8.853	1.0424	10.476	1.0491	12.071
1.0291	7.244	1.0358	8.877	1.0425	10.500	1.0492	12.095
1.0292	7.268	1.0359	8.901	1.0426	10.523	1.0493	12.119
1.0293	7.292	1.0360	8.925	1.0427	10.547	1.0494	12.142
1.0294	7.316	1.0361	8.950	1.0428	10.571	1.0495	12.166
1.0295	7.341	1.0362	8.975	1.0429	10.595	1.0496	12.190
1.0296	7.365	1.0363	9.000	1.0430	10.619	1.0497	12.214
1.0297	7.389	1.0364	9.024	1.0431	10.642	1.0498	12.238
1.0298	7.413	1.0365	9.048	1.0432	10.666	1.0499	12.261
1.0299	7.438	1.0366	9.073	1.0433	10.690	1.0500	12.285
1.0300	7.463	1.0367	9.097	1.0434	10.714	1.0501	12.309
1.0301	7.488	1.0368	9.122	1.0435	10.738	1.0502	12.333
1.0302	7.512	1.0369	9.146	1.0436	10.761	1.0503	12.357
1.0303	7.536	1.0370	9.170	1.0437	10.785	1.0504	12.381
1.0304	7.560	1.0371	9.195	1.0438	10.809	1.0505	12.404
1.0305	7.584	1.0372	9.219	1.0439	10.833	1.0506	12.428
1.0306	7.609	1.0373	9.244	1.0440	10.857	1.0507	12.452
1.0307	7.633	1.0374	9.268	1.0441	10.881	1.0508	12.476
1.0308	7.657	1.0375	9.292	1.0442	10.904	1.0509	12.500
1.0309	7.681	1.0376	9.316	1.0443	10.928	1.0510	12.523
1.0310	7.706	1.0377	9.341	1.0444	10.952	1.0511	12.547
1.0311	7.731	1.0378	9.365	1.0445	10.976	1.0512	12.571
1.0312	7.756	1.0379	9.389	1.0446	11.000	1.0513	12.595
1.0313	7.780	1.0380	9.413	1.0447	11.023	1.0514	12.619
1.0314	7.804	1.0381	9.438	1.0448	11.047	1.0515	12.642
1.0315	7.828	1.0382	9.463	1.0449	11.071	1.0516	12.666
1.0316	7.853	1.0383	9.488	1.0450	11.095	1.0517	12.690
1.0317	7.877	1.0384	9.512	1.0451	11.119	1.0518	12.714
1.0318	7.901	1.0385	9.536	1.0452	11.142	1.0519	12.738
1.0319	7.925	1.0386	9.560	1.0453	11.166	1.0520	12.761
1.0320	7.950	1.0387	9.584	1.0454	11.190	1.0521	12.785
1.0321	7.975	1.0388	9.609	1.0455	11.214	1.0522	12.809
1.0322	8.000	1.0389	9.633	1.0456	11.238	1.0523	12.833
1.0323	8.024	1.0390	9.657	1.0457	11.261	1.0524	12.857
1.0324	8.048	1.0391	9.681	1.0458	11.285	1.0525	12.881
1.0325	8.073	1.0392	9.706	1.0459	11.309	1.0526	12.904
1.0326	8.097	1.0393	9.731	1.0460	11.333	1.0527	12.928
1.0327	8.122	1.0394	9.756	1.0461	11.357	1.0528	12.952
1.0328	8.146	1.0395	9.780	1.0462	11.381	1.0529	12.976
1.0329	8.170	1.0396	9.804	1.0463	11.404	1.0530	13.000
1.0330	8.195	1.0397	9.828	1.0464	11.428	1.0531	13.023
1.0331	8.219	1.0398	9.853	1.0465	11.452	1.0532	13.047
1.0332	8.244	1.0399	9.877	1.0466	11.476	1.0533	13.07[illegible]
1.0333	8.268	1.0400	9.901	1.0467	11.500	1.0534	13.0[illegible]
1.0334	8.292	1.0401	9.925	1.0468	11.523	1.0535	13.[illegible]

BALLING'S EXTRACT TABLE—Continued.

Specific Gravity.	Per Cent Balling.	Specific Gravity.	Per Cent Balling.	Specific Gravity.	Per Cent Balling.	Specific Gravity.	Per C[ent] Balli[ng].
1.0536	13.142	1.0603	14.738	1.0670	16.302	1.0737	17.8
1.0537	13.166	1.0604	14.761	1.0671	16.325	1.0738	17 8
1.0538	13.190	1.0605	14.785	1.0672	16.348	1.0739	17.8
1.0539	13.214	1.0606	14.809	1.0673	16.371	1.0740	17.8
1.0540	13.238	1.0607	14.833	1.0674	16.395	1.0741	17.8
1.0541	13.261	1.0608	14.857	1 0675	16.418	1.0742	17.9
1.0542	13.285	1.0609	14.881	1.0676	16.441	1.0743	17.9
1.0543	13.309	1.0610	14.904	1.0677	16.464	1.0744	18.0
1.0544	13.333	1.0611	14.928	1 0678	16.488	1.0745	18.0
1.0545	13.357	1.0612	14.952	1.0679	16.511	1.0746	18.0
1.0546	13.381	1.0613	14.976	1.0680	16.534	1.0747	18.0
1.0547	13.404	1.0614	15.000	1.0681	16.557	1.0748	18.0
1.0548	13.428	1.0615	15.023	1.0682	16.581	1.0749	18.1
1.0549	13.452	1.0616	15.046	1.0683	16.604	1.0750	18.1
1.0550	13.476	1.0617	15.070	1.0684	16.627	1.0751	18.1
1.0551	13.500	1.0618	15.093	1.0685	16.650	1.0752	18.1
1.0552	13.523	1.0619	15.116	1.0686	16.674	1.0752	18.2
1.0553	13.547	1.0620	15.139	1.0687	16.697	1.0754	18.2
1.0554	13.571	1.0621	15.162	1.0688	16.721	1.0755	18.2
1.0555	13.595	1.0622	15.186	1.0689	16.744	1.0756	18.2
1.0556	13.619	1.0623	15.209	1.0690	16.767	1.0757	18.2
1.0557	13.642	1.0624	15.232	1.0691	16.790	1.0758	18.3
1.0558	13.666	1.0625	15.255	1.0692	16.814	1.0759	18.3
1.0559	13.690	1.0626	15.278	1 0693	16.837	1.0760	18.3
1.0560	13.714	1.0627	15.302	1.0694	16.860	1.0761	18.3
1.0561	13.738	1.0628	15.325	1 0695	16.883	1.0762	18.4
1.0562	13.761	1.0629	15.348	1.0696	16.907	1.0763	18.4
1.0563	13.785	1.0630	15 371	1.0697	16.930	1.0764	18.4
1.0564	13.809	1.0631	15.395	1.0698	16.958	1.0765	18.4
1.0565	13.833	1.0632	15.418	1.0699	16.976	1.0766	18.5
1.0566	13.857	1.0633	15.441	1.0700	17.000	1.0767	18.5
1.0567	13.881	1.0634	15.464	1.0701	17.022	1.0768	18.5
1.0568	13.904	1.0635	15.488	1.0702	17.045	1.0769	18.5
1.0569	13.928	1.0636	15.511	1.0703	17.067	1.0770	18.5
1.0570	13.952	1.0637	15.534	1.0704	17.090	1.0771	18 6
1.0571	13.976	1.0638	15.557	1.0705	17.113	1.0772	18.6
1.0572	14.000	1.0639	15.581	1.0706	17.136	1.0773	18.6
1.0573	14.022	1.0640	15.604	1.0707	17.158	1.0774	18.6
1.0574	14.047	1.0641	15.627	1.0708	17.181	1.0775	18.7
1.0575	14.071	1.0642	15.650	1.0709	17.204	1.0776	18.7
1.0576	14.095	1.0643	15.674	1.0710	17.227	1.0777	18.7
1.0577	14.119	1.0644	15.697	1 0711	17.250	1.0778	18.7
1.0578	14.142	1.0645	15.721	1.0712	17.272	1.0779	18.7
1.0579	14.166	1.0646	15.744	1.0713	17.295	1.0780	18.8
1.0580	14.190	1.0647	15.767	1.0714	17.318	1.0781	18.8
1.0581	14.214	1.0648	15.790	1.0715	17.340	1.0782	18.8
1.0582	14.238	1.0649	15.814	1.0716	17.363	1.0783	18.8
1.0583	14.261	1.0650	15.837	1.0717	17.386	1.0784	18 9
1.0584	14.285	1.0651	15.860	1.0718	17.409	1.0785	18.9
1.0585	14.309	1.0652	15.883	1.0719	17.431	1.0786	18 9
1.0586	14.333	1.0653	15.907	1.0720	17.454	1.0787	18.9
1.0587	14.357	1.0654	15.930	1.0721	17.477	1.0788	19.0
1.0588	14.381	1.0655	15.953	1.0722	17.500	1.0789	19.0
1.0589	14.404	1.0656	15.976	1.0723	17.522	1.0790	19.0
1.0590	14.428	1.0657	16.000	1.0724	17 545	1.0791	19.0
1.0591	14.452	1.0658	16.023	1.0725	17.568	1.0792	19 0
1.0592	14.476	1.0659	16.046	1.0726	17.590	1.0793	19.1
1.0593	14.500	1.0660	16.070	1.0727	17.613	1.0794	19.1
1.0594	14.523	1.0661	16.093	1.0728	17.636	1.0795	19.1
1.0595	14.547	1.0662	16.116	1.0729	17.659	1.0796	19.1
1.0596	14.571	1.0663	16.139	1.0730	17.681	1.0797	19.2
1.0597	14.595	1.0664	16.162	1.0731	17.704	1.0798	19.2
1.0598	14.619	1.0665	16.186	1.0732	17.727	1 0799	19.2
1.0599	14.642	1.0666	16.209	1 0733	17.750	1.0800	19.[illegible]
1.0600	14.666	1.0667	16.232	1.0734	17.772		
1.0601	14.690	1.0668	16.255	1.0735	17.795		
1.0602	14.714	1.0669	16.278	1 0736	17.818		

F. ALLIHN'S DEXTROSE TABLE.

Copper.	Dextrose.	Copper.	Dextrose.	Copper.	Dextrose.	Copper.	Dextrose.
mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg.
10	6.1	67	34.3	124	63.1	181	92.6
11	6.6	68	34.8	125	63.7	182	93.1
12	7.1	69	35.3	126	64.2	183	93.7
13	7.6	70	35.8	127	64.7	184	94.2
14	8.1	71	36.3	128	65.2	185	94.7
15	8.6	72	36.8	129	65.7	186	95.2
16	9.0	73	37.3	130	66.2	187	95.7
17	9.5	74	37.8	131	66.7	188	96.3
18	10.0	75	38.3	132	67.2	189	96.8
19	10.5	76	38.8	133	67.7	190	97.3
20	11.0	77	39.3	134	68.2	191	97.8
21	11.5	78	39.8	135	68.8	192	98.4
22	12.0	79	40.3	136	69.3	193	98.9
23	12.5	80	40.8	137	69.8	194	99.4
24	13.0	81	41.3	138	70.3	195	100.0
25	13.5	82	41.8	139	70.8	196	100.5
26	14.0	83	42.3	140	71.3	197	101.0
27	14.5	84	42.8	141	71.8	198	101.5
28	15.0	85	43.4	142	72.3	199	102.0
29	15.5	86	43.9	143	72.9	200	102.6
30	16.0	87	44.4	144	73.4	201	103.2
31	16.5	88	44.9	145	73.9	202	103.7
32	17.0	89	45.4	146	74.4	203	104.2
33	17.5	90	45.9	147	74.9	204	104.7
34	18.0	91	46.4	148	75.5	205	105.3
35	18.5	92	46.9	149	76.0	206	105.8
36	18.9	93	47.4	150	76.5	207	106.3
37	19.4	94	47.9	151	77.0	208	106.8
38	19.9	95	48.4	152	77.5	209	107.4
39	20.4	96	48.9	153	78.1	210	107.9
40	20.9	97	49.4	154	78.6	211	108.4
41	21.4	98	49.9	155	79.1	212	109.0
42	21.9	99	50.4	156	79.6	213	109.5
43	22.4	100	50.9	157	80.1	214	110.0
44	22.9	101	51.4	158	80.7	215	110.6
45	23.4	102	51.9	159	81.2	216	111.1
46	23.9	103	52.4	160	81.7	217	111.6
47	24.4	104	52.9	161	82.2	218	112.1
48	24.9	105	53.5	162	82.7	219	112.7
49	25.4	106	54.0	163	83.3	220	113.2
50	25.9	107	54.5	164	83.8	221	113.7
51	26.4	108	55.0	165	84.3	222	114.3
52	26.9	109	55.5	166	84.8	223	114.8
53	27.4	110	56.0	167	85.3	224	115.3
54	27 9	111	56.5	168	85.9	225	115.9
55	28.4	112	57.0	169	86.4	226	116.4
56	28.8	113	57.5	170	86.9	227	116.9
57	29.3	114	58.0	171	87.4	228	117.4
58	29.8	115	58.6	172	87.9	229	118.0
59	30.3	116	59.1	173	88.5	230	118.5
60	30.8	117	59.6	174	89.0	231	119.0
61	31.3	118	60.1	175	89.5	232	119.6
62	31.8	119	60.6	176	90.0	233	120.1
63	32.3	120	61.1	177	90.5	234	120.7
64	32.8	121	61.6	178	91.1	235	121.2
65	33.3	122	62.1	179	91.6	236	121.7
66	33.8	123	62.6	180	92.1	237	122.3

F. ALLIHN'S DEXTROSE TABLE—Continued.

Copper.	Dex-trose.	Copper.	Dex-trose.	Copper.	Dex-trose.	Copper.	Dex-trose.
mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg
238	122.8	295	153.8	352	185.4	409	218.
239	123.4	296	154.3	353	186.0	410	218.
240	123.9	297	154.9	354	186.6	411	219.
241	124.4	298	155.4	355	187.2	412	219.
242	125.0	299	156.0	356	187.7	413	220.
243	125.5	300	156.5	357	188.3	414	221.
244	126.0	301	157.1	358	188.9	415	221.
245	126.6	302	157.6	359	189.4	416	222.
246	127.1	303	158.2	360	190.0	417	222.
247	127.6	304	158.7	361	190.6	418	223.
248	128.1	305	159.3	362	191.1	419	223.
249	128.7	306	159.8	363	191.7	420	224.
250	129.2	307	160.4	364	192.3	421	225.
251	129.7	308	160.9	365	192.9	422	225.
252	130.3	309	161.5	366	193.4	423	226.
253	130.8	310	162.0	367	194.0	424	226.
254	131.4	311	162.6	368	194.6	425	227.
255	131.9	312	163.1	369	195.1	426	228.
256	132.4	313	163.7	370	195.7	427	228.
257	133.0	314	164.2	371	196.3	428	229.
258	133.5	315	164.8	372	196.8	429	229
259	134.1	316	165.3	373	197.4	430	230
260	134.6	317	165.9	374	198.0	431	231.
261	135.1	318	166.4	375	198.6	432	231.
262	135.7	319	167.0	376	199.1	433	232.
263	136.2	320	167.5	377	199.7	434	232.
264	136.8	321	168.1	378	200.3	435	233.
265	137.3	322	168.6	379	200.8	436	233
266	137.8	323	169.2	380	201.4	437	234.
267	138.4	324	169.7	381	202.0	438	235.
268	138.9	325	170.3	382	202.5	439	235.
269	139.5	326	170.9	383	203.1	440	236.
270	140.0	327	171.4	384	203.7	441	236.
271	140.6	328	172.0	385	204.3	442	237.
272	141.1	329	172.5	386	204.8	443	238.
273	141.7	330	173.1	387	205.4	444	238.
274	142.2	331	173.7	388	206.0	445	239.
275	142.8	332	174.2	389	206.5	446	239.
276	143.3	333	174.8	390	207.1	447	240.
277	143.9	334	175.3	391	207.7	448	241.
278	144.4	335	175.9	392	208.3	449	241.
279	145.0	336	176.5	393	208.8	450	242.
280	145.5	337	177.0	394	209.4	451	242.
281	146.1	338	177.6	395	210.0	452	243.
282	146.6	339	178.1	396	210.6	453	244.
283	147.2	340	178.7	397	211.2	454	244.
284	147.7	341	179.3	398	211.7	455	245.
285	148.3	342	179.8	399	212.3	456	245.
286	148.8	343	180.4	400	212.9	457	246.
287	149.4	344	180.9	401	213.5	458	246.
288	149.9	345	181.5	402	214.1	459	247.
289	150.5	346	182.1	403	214.6	460	248.
290	151.0	347	182.6	404	215.2	461	248.
291	151.6	348	183.2	405	215.8	462	249.
292	152.1	349	183.7	406	216.4	463	249.
293	152.7	350	184.3	407	217.0		
294	153.2	351	184.9	408	217.5		

THE BREWER'S MICROSCOPICAL LABORATORY.

EQUIPMENT.

APPARATUS.

Balance with a capacity of 1 kg., and sensitive to 1 cg. Should be incased in a wooden case with glass sides.

Microscope with a magnifying power of 60 to 500 diameters.

Slides are glass slips generally about three inches long and one inch wide, on which the objects under examination are placed.

Cover glasses are round or square very thin pieces of glass, and are used for covering the object after it has been placed on the slide.

Cover glasses and slides are cleaned before using by immersing

Hæmatimeter (Yeast Counting Apparatus).

them in a mixture of equal parts of ammonia water and alcohol, afterward drying them with a soft linen rag.

Haematimeter for counting yeast cells or bacteria in beer. It is composed of a slide, in the center of which a square cover glass, 0.2 millimeters thick, having a circular opening, is cemented. Inside of this opening, and concentric to it, is also cemented another round cover glass of one-half its thickness (0.1 millimeter). By covering the larger cover glass with a third, a space of 0.1 millimeter is formed between the thin, small glass and the cover glass, which space serves as a receptacle for holding the liquid to be examined. The deeper circular space formed be-

tween the slide and cover glass holds any excess liquid squeez out of the 0.1 millimeter space.

The thinner, smaller disc of glass is so marked with cro lines as to furnish 400 squares, the total covering a surface 1 square millimeter so that the volume of liquid between t marked surface and the cover glass will be 0.1 cubic millimete

Platinum Needle. This consists of a piece of platinum wir one end of which is imbedded, by melting, into the end of a gla rod, and is used for transferring or distributing samples of su stances to be examined.

Forceps, preferably nickel-plated.

Hansen Flask.

Freudenreich Flask.

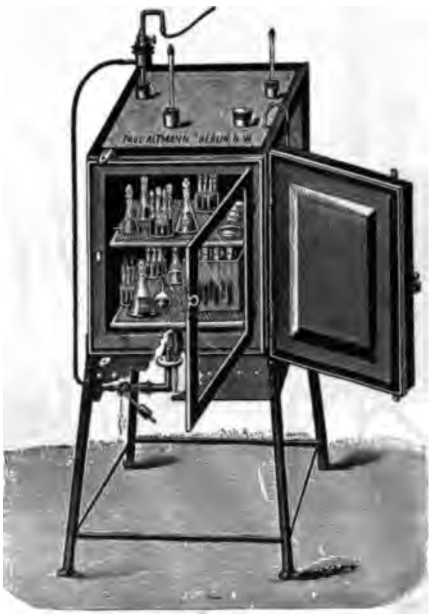
Henius Flask.

Incubator or Thermostat is an apparatus in which a consta temperature can be maintained, such as is required in biologic investigations. It is made either of copper or galvanized iro and provided with double walls the space between which filled with distilled water, or, preferably, in order to diminish t evaporation, with a mixture of glycerin and water.

For regulating the heat a *thermo-regulator* is employed, co sisting of a glass tube containing mercury through which the g passes. The higher the mercury rises, due to expansion by hea ing, the less gas is allowed to pass out of the tube, and inverse thus regulating the size of the flame by which the incubator heated.

Hot-air Sterilizer. This apparatus is used for sterilizing the flasks and other vessels. It is usually constructed of copper or galvanized iron, with double walls, and supplied with ventilators at the top for controlling the temperature. For this purpose a thermometer, with a scale reaching to 400° F., should be employed.

Steam Sterilizer. For sterilizing liquids and other substances



Incubator.

used in the cultivation of micro-organisms, where no higher temperature than that of boiling water is desired. This apparatus is made of iron or copper, like the hot-air sterilizer. The interior is divided into two chambers, with an opening for inserting a thermometer.

Apparatus for Determining the Fermenting Power of Yeast. *This device consists of a copper water bath, two-quart bottles*

two sulphuric acid bulbs, with rubber stoppers, thermomet
thermo-regulator and Bunsen burner.

Water Bottle for holding distilled water.

Glass Beakers having a capacity of from one to four ounces.

Erlenmeyer Flasks; capacity, two to eight ounces.

Petri Dishes; flat glass dishes, fitting into each other, used
drop cultures, gelatin plates, etc.

Hot-air Sterilizer.

Pasteur Flask.

Drop Culture Slides; glass slips with cavity in the center, fo
drop or droplet cultures.

Moist Chambers. Böttcher, consisting of a glass ring cemente
on a glass slide. Used mainly for yeast culture.

Pipettes, small glass tubes of one c.c. capacity, divided in
tenths, for drop cultures and water examinations.

Freudenreich or Hansen Flasks, for cultivation of yeasts ar
other micro-organisms in sterilized liquids. The *Henius Flas*
is of very simple construction and answers the same purpose
(*see illustration*).

Test Tubes for cultivation of micro-organisms, for samples

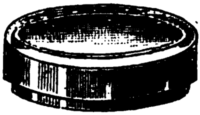
beer, wort or yeast. The tubes are closed with absorbent cotton before sterilizing.

Gypsum Blocks for spore cultures.

Steam Sterilizer.

REAGENTS.

Iodine Solution for testing for starch. Starch is colored blue when brought in contact with this solution. It is prepared as follows: Six grains (35 cg.) of iodine and 16 grains (1 gram)



Petri Dish.

Drop Culture Slide.

of potassium iodide are mixed in a mortar, gradually adding enough distilled water to make 5 fluid ounces (160 c.c.) of solution. *It should be kept in a well-closed bottle and not exposed to the light.*

Potassium-Hydrate Solution **for dissolving albumen and ho resin particles. One part potassium hydrate is dissolved nine parts distilled water.**

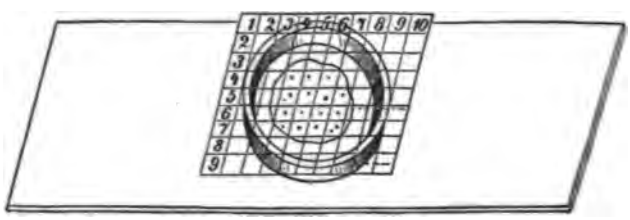
Apparatus for Testing Fermenting Power of Yeast.

Iron Chloride Solution for detecting tannic acid. One p iron chloride is dissolved in nine parts of distilled water.

STAINS.

Stains are used for the purpose of:

1. Distinguishing dead yeast cells from live ones.
2. Recognizing the bacteria more plainly.



Moist Chamber (according to Thausing).

For staining purposes aniline colors are employed, and among these most commonly Eosine, Methylene Blue, Gentian Vio and Fuchsine.

Eosine Solution, used in the examination of yeasts for de cells. Sixteen grains (1 gram) of eosine is dissolved in

drachms (10 c.c.) of alcohol and enough water added to make 3.5 ounces (100 c.c.) solution.

PREPARATION OF STAINS FOR BACTERIA.

Concentrated Alcoholic Solutions:

Methylene Blue, 80 grains (5 grams) in 3.5 ounces (100 c.c.) of alcohol.

Gentian Violet, 112 grains (7 grams) (in 3.5 ounces (100 c.c.) of alcohol.

Fuchsine, 240 grains (15 grams) in 3.5 ounces (100 c.c.) of alcohol.

The aniline color is shaken for some time with the alcohol, allowed to settle, and the clear solution poured off.

From these concentrated solutions, too strong to be used for staining, the aqueous solutions are made. One part of the concentrated solution is diluted with four parts of distilled water.

For general staining of the micro-organisms the following solutions are usually employed:

Ziehl's Carbol-Fuchsine.

Fuchsine, 1 gram.
Carbolic acid, 5 grams.
Alcohol, 10 grams.
Distilled water, 100 grams.

Loeffler's Methylene Blue Solution.

Concentrated solution of methylene blue, 30 c.c.
Potassium hydrate solution (0.01 per cent), 100 c.c.

The staining solutions are best kept in medicine bottles of about two ounces' capacity, closed with corks, through which a small pipette or glass tube has been inserted. They should be kept in a dark place.

CULTURE MEDIA.

By this term is understood liquids or solids containing substances which serve as nourishment for the micro-organisms under examination. For the cultivation of moulds and yeasts the substances usually employed are *wort, beer* and *wort gelatin.* As a large number of bacteria require for their development culture media of a neutral or alkaline reaction, they will not grow *in beer or wort,* as these media have an acid reaction. For cu

tivating these bacteria the substances used are *meat-water* (*bouillon*) and *meat-water gelatin*.

Wort.—Usually hopped wort is used; must be perfectly clear; if this cannot be obtained by filtration, it is necessary to clarify the wort with egg-albumen. To one quart (1,000 c.c.) of wort add 50 grains (3 grams) of dried egg-albumen, shake the mixture till the albumen has dissolved, then boil until a perfect break has been produced, cool and filter. The clear wort is poured into Freudenreich flasks (10 c. c. in each), which are then sterilized in steam for half an hour.

Beer.—Of clear finished beer 10 c.c. is measured into a Freudenreich flask and sterilized at 150° F. for 20 minutes on three successive days.

Wort Gelatin. Three ounces (100 grams) of gelatin is allowed to soak with one quart (1,000 c.c.) of hopped wort for one hour, and then heated in steam till perfect solution takes place. As soon as the mixture has cooled somewhat, 50 grains (3 grams) of egg-albumen, previously dissolved in water, is added, the mixture boiled again till a perfect break has been obtained, and then filtered warm. The clear filtrate is filled into test tubes, in amounts of 5 to 10 c.c. in each, and sterilized like beer.

Meat-Water (*Bouillon*).—One pound chopped lean beef is boiled with one quart of water for one hour, water being added to make up for evaporation, and then pressed until one quart of liquid has been obtained. This liquid, to which 160 grains (10 grams) of peptone and 80 grains (5 grams) of salt are added, is boiled in steam for three-quarters of an hour, then made slightly alkaline with sodium hydrate solution, heated up to boiling and filtered. The filtrate should be perfectly clear, of light yellow color, and have a slightly alkaline reaction. Sterilize it like beer.

Meat-Water Gelatin.—Like the preceding, with the addition of 10 per cent gelatin.

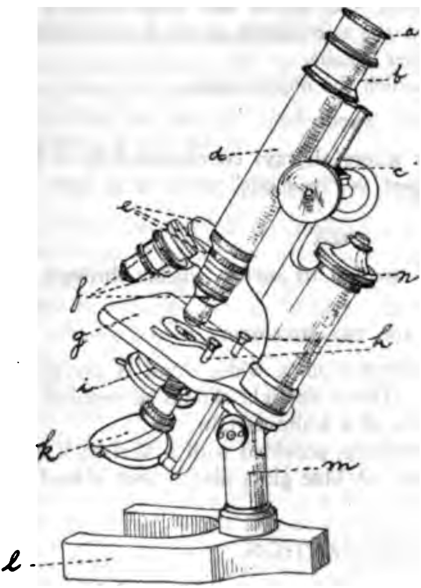
Agar-Agar.—As gelatin melts easily at higher temperatures besides being liquefied by many organisms, it is often practical to replace it with agar-agar (1 to 1.5 per cent). This substance, which is not liquefied by any organism, dissolves only after boiling for a prolonged time, such solution being very difficult of filtration.

THE COMPOUND MICROSCOPE.

This instrument is composed of the following principal parts:

Objective, so called because it is nearest to the object under examination, is composed of two or more plano-convex lenses.

Ocular or eyepiece is composed of two plano-convex lenses. This receives the magnified image from the objective and magnifies it further.



a. Ocular or eye-piece.
b. Draw tube.
c. Rack and p'nion.
d. Tube.
e. Triple nose-piece.
f. Objectives.
g. Stage.
h. Cl'ps.
i. Condenser with iris diaphragm.
k. Plain and concave mirror
l. Foot.
m. Pillar.
n. Micrometer screw.

Compound Microscope.

Mirror is used for throwing light on the object under examination. Composed of two mirrors, one of which is plane, the other concave. The former is used for lower magnifying power and the latter for higher.

Diaphragm regulates the amount of light. The larger the opening, the more light is thrown on the object.

The "Iris-diaphragm" consists of a series of thin blades overlapping each other and placed so that a central opening is formed, which can be made larger or smaller by means of a lever.

Abbe Illuminating Apparatus consists of mirror, iris-diaphragm and a system of lenses, or so-called "condenser."

Base or *Foot* serves for keeping the microscope firmly in position.

Tube or *Tubes* hold the ocular and objective at the proper distance from each other.

Large Screw is used for focusing the object roughly.

Micrometer Screw.—After the object has been focused by means of the large screw, the micrometer screw is employed in order to bring out the finer details.

Stage is that part on which the object rests.

FOCUS.

The focus is the point where all rays concentrated by a lens or mirror meet. An object is "in focus" when it is seen the clearest.

FIELD.

Field (of view) is the amount of surface visible through the microscope.

LIGHT FOR THE MICROSCOPE.

The light which is received from a white cloud is preferable to that from the blue sky. Direct sunlight should be avoided unless it is subdued by means of a white curtain.

For artificial light, a gas lamp, provided with a Welsbach burner, is to be recommended. A blue glass disc is then placed on the diaphragm.

STERILIZATION.

Sterilization is the process by which germs contained in liquids or solids are destroyed or removed. The method employed depends on the nature and condition of the object to be sterilized, or made sterile, i. e., free from germs.

Simple utensils, as glass rods or platinum needles, are sterilized by heating them in a gas flame for a short time.

Petri dishes, glass flasks, test tubes, etc., are sterilized in a dry-heat sterilizer for one hour and a half at 300° F., the openings of bottles and tubes being closed with cotton before sterilizing.

Larger closed vessels are either sterilized by boiling water in

[redacted]

them or by direct steam, the openings being closed with sterilized cotton or cotton filters.

Water is sterilized by direct boiling for half an hour.

Air is sterilized by passing through a filter containing sterilized cotton, the germs being retained in the cotton.

Culture media (wort) are sterilized by heating in the steam sterilizer for half an hour. Gelatin is best sterilized by keeping for 20 minutes at 150° F, on three successive days. The object in this interrupted method is to destroy the spores of those organisms that survive the first heating and develop subsequently, being then less resistant.

Liquids can also be made germ-free by filtration through porcelain or clay filters.

STAINING BACTERIA.

A small quantity of the substance under examination is distributed uniformly in a drop of water on a cover glass, and dried by gently heating over a gas flame. The cover glass is then drawn slowly, three times, through the flame, then enough staining solution added, so that the cover glass is covered with the same. After one-half to one minute the staining solution is washed off with water, the preparation is then dried with filter paper and placed in a drop of water on a slide with the stained side downward. If it is desired to keep the preparation permanently, the water is removed entirely from the cover glass, which is then cemented to a slide by a drop of a mixture consisting of equal parts of Canada balsam and xylol.

PURE CULTURES OF MICRO-ORGANISMS.

A pure culture is a culture containing one species only, and consequently consists of the progeny of one single cell.

For making pure cultures of micro-organisms, the following methods may be followed:

PLATE CULTURE.

The gelatin contained in two test tubes is liquefied at 95° F. By means of the platinum needle a small quantity of the material is introduced in one of the test tubes, and thoroughly mixed with the gelatin. The platinum needle is dipped in this *mixture several times*, and each time inserted in the second tub

with gelatin, which is also thoroughly mixed by gently shaking The contents are then poured into a sterilized Petri dish.

STREAK CULTURE.

A test tube of gelatin is liquefied and poured into a Petri dish. The platinum needle is dipped into the liquid containing the micro-organisms and drawn carefully over the surface of the hardened gelatin three or four times. The colonies from the last streaks are more widely separated from each other and often are pure cultures.

DILUTION METHOD, ACCORDING TO HANSEN.

A small quantity of yeast is diluted so far with sterilized water, that each drop contains about 10 yeast cells. A drop of this mixture is transferred to a flask containing 20 c.c. sterilized water, and thoroughly shaken. This mixture will then contain about 10 yeast cells. Twenty flasks containing sterilized wort are prepared, and 1 c.c. of the diluted yeast introduced in each flask. The inoculated flasks are shaken thoroughly, and then left standing at 77° F. Those flasks, which after two or three days show only one colony at the bottom, contain pure cultures.

GELATIN OR MOIST CHAMBER METHOD, ACCORDING TO HANSEN.

Liquefied wort gelatin is mixed with a small quantity of yeast which has first been strengthened in sterilized wort. The mixture should be so far diluted that a drop placed on a slide and examined under the microscope with a magnifying power of about 100 diameters will show only few and well-isolated cells. A drop of the gelatin mixture is then spread on a cover glass that has been sterilized by heating in a flame, and placed on a moist chamber with the gelatin downward. On the bottom of the chamber a small drop of sterilized water is placed in order to furnish enough moisture, and an air-tight connection between cover glass and ring made by vaseline.

The positions of those cells in the gelatin, which are sufficiently free and isolated, are marked while under the microscope, and their growth noted from day to day, in order to ascertain if any other yeast cells or bacteria develop in the neighborhood of the marked cells. If this is not the case, the colonies developed from these cells can later be used as pure cultures.

DROPLET CULTURE METHOD, ACCORDING TO LINDNER.

The yeast is diluted with sterilized wort or a mixture of wort and wort-gelatin. By means of a sterilized drawing pen, dipped into the liquid, 30 to 40 little points or dashes are put on a cover glass in four or five rows. The glass is now placed on a moist chamber and kept at 77° F. The yeast should, if necessary, be diluted so that the droplets contain only a very few cells. Those which only contain one cell are noted by numbers, controlled under the microscope, and, if pure, the colonies can be transferred, by means of the platinum needle, to sterilized wort.

EXAMINATIONS OF MATERIALS.

RICE.

For adulteration with corn. The sample is ground as fine as possible, a small quantity distributed in a drop of water on a slide, covered with cover glass, and examined with a magnifying power of 250 to 300 diameters. The starch granules of rice are much smaller than those of corn, and are sharp-edged, while the granules of the latter are round-edged, and often have an opening in the center. (See "Brewing Materials," 471, 472.)

ISINGLASS.

For starch. A small piece of the sample is placed in a drop of iodine solution. If starch was added to the isinglass, the grains appear blue, while the rest is colored yellow. Should be examined with a magnifying power of about 60 diameters.

Clarifying Test.—50 cg. (8 grains) is cut into small pieces and soaked for one hour in 5 c.c. of water (in case of fish isinglass 10 cg. (2 grains) of tartaric acid should be added). After soaking is finished 5 c.c. of boiling water, and then 10 c.c. of beer is added. Of this mixture 2 c.c. is added to one pint of beer. The bottle is allowed to stand for 48 hours in a cold place, after which the clarifying power of the isinglass is noted. If the isinglass is of good quality the beer should appear clear and the isinglass have settled on the bottom.

LUPULIN.

For tannic acid. A small quantity is mixed with a little water and a few drops of iron chloride solution added. If tannic acid has been mixed with the lupulin, the mixture will assume a *bluish-black color on being brought in contact with the iron chloride.*

For sand. The sample is shaken with water in a test tube and allowed to stand for a few minutes. The sand being heavier will settle to the bottom while most of the lupulin remains on the top of the liquid. If the sediment is examined microscopically, the grains of sand appear colorless and sharp-edged, while the lupulin is yellow and round. Should be examined with a magnifying power of 80 to 100 diameters. A good sample of lupulin should contain but little sand. (See "Brewing Materials.")

BARLEY, MALT AND HOPS.

For mold. The examination is carried on with low magnifying power (about 60 diameters). If mold is present it will appear as fine cobweb-like threads. These can be removed by means of a needle, and are best subjected to microscopical examination in a drop of glycerin at a magnifying power of about 150 to 300 diameters.

To stain molds, Loeffler's alkaline solution of methylene blue, which stains the mycelium, but not the spores, is to be preferred.

WATER EXAMINATION.

A turbid, foul-smelling water cannot be used for brewing purposes. The turbidity and bad odor are usually caused by the action of micro-organisms. But often a water appears clear and free from any odor, and yet contains large numbers of germs, many of which can do extensive damage in the brewery.

In order to ascertain if a water is suitable for brewing purposes, it should be subjected to a microscopical and bacteriological examination.

If the water shows turbidity or particles in suspension, it is advisable to gather the flakes or particles by allowing them to settle in a sedimentation glass. The clear water can be poured off and the sediment subjected to microscopical examination. Among the substances most commonly found in such sediments, besides bacteria and yeast cells, are infusoria, diatoms, various colorless algæ, among them the so-called water pest (crenothrix) and molds. In addition to living organisms, inorganic matter, as sand and iron, often occurs in the sediment.

Simple microscopical examination is not sufficient for the purpose of determining the number of micro-organisms that may be contained in a sample of water, the number in a single drop be-

ing frequently too small to allow any accurate results being reached. It is therefore necessary to employ the bacteriological examination, which can be made in different ways.

For Hygienic Purposes.—Meat-water gelatin is used. A certain quantity of the water is mixed with the liquefied gelatin and poured into a sterilized Petri dish, allowed to become solid, and kept at ordinary temperature for a few days, after which the colonies developed from the micro-organisms contained in the water are counted and their species determined.

This examination is of no interest to the brewer, as this culture medium is not employed in the production of beer. What the brewer wants to know is, how many and what kind of organisms are present in the water that are capable of developing in wort and beer, and as a large number of those organisms which will grow in meat-water gelatin cannot develop in beer or wort, the results obtained by the meat-water gelatin examination would be either worthless or misleading to the brewer.

The simplest way of examining a water *for brewing purposes* is Lindner's drop culture method.

LINDNER'S DROP CULTURE METHOD.

Ten c.c. sterilized wort is measured off in a test tube by means of a sterilized pipette. One c.c. of the water is then added to the wort by means of a pipette of 1 c.c. capacity, subdivided into 1-10 c.c. The mixture is thoroughly stirred by drawing up in the pipette and allowing it to run out, repeating this process till the germs are well distributed. The water is thus diluted 11 times. By means of the same pipette the two plates of a Petri dish are covered with small drops of the mixture, and the amount used, whether 1 c.c. or a fraction of 1 c.c., is noted. The dishes can be kept at ordinary temperature under a glass globe under which a small vessel of water has been placed, in order to prevent drying up. After two or three days the germs will have developed enough to make a number of the drops turbid. The turbid ones are counted, and give the number of germs contained in the amount of diluted water used. Suppose that 100 drops made 1 c.c., and 50 colonies developed, then there were 11 times as many germs contained in 1 c.c. of the original water. If all the drops became turbid, a new examination should be made

diluting the water a greater number of times with wort befor making the cultures.

The turbid drops should be subjected to microscopical examination, so that a general idea of the character of the infection ma be obtained.

HANSEN'S METHOD OF WATER EXAMINATION.

Hansen's investigations showed that not all the germs, whic will develop in wort gelatin, are capable of growing in wort o beer. Besides, the water can contain organisms which will thriv very well in wort or beer, but not in wort gelatin. If wort gelatin is used for the examination of brewing waters, the result might, therefore, be misleading, as they would not correspon with the conditions found in the brewery.

To overcome this difficulty the following method was devised

Fifteen Freudenreich flasks, each containing 20 c.c. of wort another fifteen, each containing 20 c.c. of beer, and one containing 5 c.c. of wort, are sterilized by steam. To the 5 c.c. of steril wort are now added 5 c.c. of the water to be examined and mixe thoroughly.

Measure 20 c.c. of wort into each of 15 Freudenreich flask and 20 c.c. of beer into each of 15 other similar flasks, and sterilize in steam. To 5 c.c. wort sterilized the same way, and contained in another flask, add 5 c.c. of the water and mix thoroughly Of this mixture, one drop (0.04 c.c.) is added to each of th 30 wort and beer flasks by means of a sterilized pipette. Th flasks are kept at a temperature of 77° F. for 14 day after which they are examined. If only some of the flasks hav become turbid, there is reason to believe that each of these contained only one germ, but if all the bottles have turned, it i necessary to repeat the examination with a correspondingl smaller quantity of water and larger quantity of sterilized wor

As each of the flasks received 0.04 c.c. of the mixture o wort and water, we are enabled by the number of turbid flasks t approximately determine the number of germs capable of development in wort or beer.

Suppose that the mixture was made of equal volumes of wor or beer and water, the amount of water used for 15 flasks woul then be

$$\frac{15 \times 0.04}{2} = 0.3 \text{ c.c. water.}$$

If, for instance, 5 flasks become turbid, there would be 5 germs in 0.3 c.c. water, or about 17 germs per c.c.

WICHMANN'S METHOD OF WATER EXAMINATION.

Wichmann's method aims at the determination, not of the number of germs contained in the water, but of the energy with which such germs are able to attack the beer or wort. This is the determination of the so-called destructive power of a water on wort or beer. Four flasks each with 10 c.c. of either sterilized wort or beer are inoculated with 1, ¾, ½ and ¼ c.c. of the water, and placed at 77° F. for five days, during which some or all the flasks become turbid. If now the respective numbers (1, 2, 3, 4) of the flasks are multiplied by factors for which the figures 10, 8, 6, 4 and 2 were chosen, corresponding to the degree of turbidity appearing in the flasks after the first, second, third, fourth or fifth day, and the products added, the sum of the products gives the expression for the destructive power of the water. The following example shows how this result is calculated:

Wort flask. No.	Turbid after days.	Turbidity factor for the day.	Product from number and factor.
1	2	8	$1 \times 8 = 8$
2	3	6	$2 \times 6 = 12$
3	3	6	$3 \times 6 = 18$
4	4	4	$4 \times 4 = 16$
Destructive power of the water for wort			$= 54$

When using beer, which does not become turbid so readily as wort, Wichmann multiplies the figure found as above with 1.67, and calls the product the destructive power of the water on beer.

AIR EXAMINATION.

Micro-organisms are not only carried into the brewery with the raw materials, but also, to a great extent, by the air. The number of germs contained in the air differs considerably according to time, temperature and altitude. The air is purest when all dust has been carried to the ground by rain; most impure when the wind raises dust. Regular air examinations are very instructive to the brewer. They enable him to learn to what extent the air in the brewery is contaminated, and whether this contamination has its origin in the brewery itself, or comes from *outside.*

The simplest way of examining the air is to expose in a Petri dish containing wort gelatin, for a certain length time. After three to five days the colonies, which have develop from the germs falling down on the gelatin, are counted. A cording to Petri, the germs contained in 10 liters of air sett down on 100 sq. c. of gelatin in from three to five minute If wort gelatin is used molds and yeast will develop to a great extent. Hence, it is better to employ sterilized wort or bee This is done as follows:

In one of the plates of a Petri dish 10 c.c. sterilized wo is measured off. This plate is exposed to the air for ten to fi teen minutes, care being taken that no dust falls on the cove The number of germs which have dropped into the wort can l determined by making a drop culture of the infected wort. B means of a sterilized pipette the wort is mixed thoroughly an afterward distributed in small drops in another Petri dish, so as t make about 100 drops in all. The amount of wort used noted and the culture kept at ordinary temperature. After thr to four days the number of turbid drops is counted, some which may have more than one colony.

Supposing forty drops became turbid, of which five had tw colonies each, the forty one each, then $40 + (2 \times 5) =$ germs developed in 100 drops. If three c.c. wort ha been required to make the 100 drops there would altogeth be $\frac{45 \times 10}{3} = 150$ germs that fell from the air into the 10 c.c. wort of the first Petri dish.

If air contains more than 10 germs per liter it is to be con sidered too impure for use in the brewery.

MICROSCOPICAL AND BOTANICAL EXAMINATIO OF YEAST.

In the examination of yeast the following points should l kept in view:

Purity, that is, absence of organisms, and admixtures of uno ganized matter, as albuminoids, particles of hop-resin, star *grains*, oxalate of lime.

Condition, whether strong or weak.

Fermenting Power.

INDICATIONS OF SOUND, WEAK OR DEAD CELLS.

With the aid of a sterilized platinum needle a sufficient quantity of yeast is distributed in a drop of distilled water on a slide and subjected to microscopical examination. The yeast cells appear as larger or smaller oval or round bodies, some of which show one or more buds, which appear as protuberances of the cell wall. The contents of the cells consist of a clear, homogeneous substance (protoplasm), surrounded by a membrane which is the cell wall.

Strong and vigorous cells appear well filled with protoplasm. If there are specks filled with cell sap (vacuoles) it indicates that the yeast is getting weak. If the cell content is strongly granulated, the cell shriveled and pointed at the ends, and appearing like having a double cell wall, it is dead. As aniline dyes are taken up only by dead cells these stains can be used to determine the number of dead cells in a yeast. A drop of yeast is mixed with two to three drops of eosine solution and allowed to stand for a few minutes. Then the mixture is diluted with sufficient water, so that after a microscopical preparation has been made, from 100 to 150 cells are seen in each field. By counting the number of stained and unstained cells, the dead ones appearing stained, while the live cells remain unstained, until about 1,000 cells, altogether, have been counted, the approximate number of dead cells contained in the yeast is obtained. This counting should be repeated in two or three different preparations in order to get a correct average of dead cells.

A good yeast should not contain more than 50 dead cells per 1,000 yeast cells.

DETECTING IMPURITIES.

The presence of bacteria, albuminoids, hop-resin, starch and oxalate of lime can also be detected by microscopical examination.

Albuminoids and hop-resin particles appear as larger or smaller bodies of irregular shape, which are dissolved by adding a small drop of potassium hydrate solution to the preparation. If an alcoholic tincture of alkanet root is added, the hop-resin particles will assume a red color.

Starch granules can be recognized by an addition of iodine solution *by which they* are colored blue.

Crystals of oxalate of lime **appear as small, quadrangular, c orless bodies.**

Bacteria.**—As small particles of albuminoids or glutin can easily mistaken for bacteria, it is necessary to remove them l fore the yeast is examined for these organisms. For this pı pose a drop of the yeast is mixed with two drops of potassiı hydrate solution, and diluted with sufficient distilled water. F the microscopical preparation the numbers of bacteria and yeı cells in each field are noted until about 1,000 yeast cells have bı counted, and the counting is repeated in two or three prepaı tions as when counting dead cells.**

If a yeast contains more than fifteen bacteria per 1,000 cı it is to be considered too much contaminated.

If the number of bacteria in a yeast is less than one per 1,(yeast cells they are sometimes overlooked. In such cases t plate culture in Petri dishes can be employed, or still better t following method: Sterilized wort is inoculated with t sample, and the culture kept in the thermostat at 77° F., and a for some time after fermentation is over. If the yeast w free from bacteria the fermented wort will remain clear, ev after being kept several days in the incubator, no film formi on the surface, and no bacteria will be found in the yeast seı ments. On the other hand, if living bacteria are contained in t yeast their presence is proven by the formation either of a film, turbidity, or of both, and the sediments will contain bacteria.

Wild Yeast.—In order to determine whether a yeast conta wild yeast or not, the simple microscopical examination is r sufficient, as many varieties, according to the conditions und which they are cultivated, are capable of assuming differe forms, and it cannot, therefore, be judged with certainty, if sa sage-shaped or elongated cells are found in yeast, that these a cells of wild yeast.

The presence of wild yeast is detected by Hansen's methc which is based on the fact that the wild yeasts form their spoı more quickly than cultivated yeast. With the platinum needle small quantity of yeast is transferred to a flask containing abc 10 c.c. of sterilized hopped wort. The mixture is kept f twenty-four hours at ordinary temperature. Next day the wı is poured off and fresh sterilized wort added, and the flask

then kept at 77° F. for twenty-four hours. The yeast sediment is poured on a sterilized gypsum block, which is placed in a glass dish, half filled with sterilized water and covered with a loose glass cover. The yeast layer should be neither too thick nor too thin, as in the first case the formation of spores is hampered, and in the second case the detection of the spores is made more difficult. The culture is placed in the thermostat, where it remains for forty hours at 77° F. After this time the spores of wild yeast will have been formed, while the majority of the cultivated bottom-fermenting yeasts form their spores much later.

The cultivated top-fermenting yeasts will also form their spores after forty hours at 77° F., but the spores of these, as well as those of cultivated bottom-fermenting yeast, can easily be distinguished from those of wild yeast. The young spores of wild yeast have an indistinct cell wall, while the contents are strongly refractive and of an homogeneous nature. The spores of cultivated yeast are larger, have a distinct wall, and the contents are granulated and show vacuoles.

Mycoderma.—If a yeast is to be examined for mycoderma, a small quantity is inoculated in sterilized wort, and the flask placed at 77° F. for two to three days. If mycoderma is present a thick, greyish-white film will form on the surface of the wort, and the microscopical examination of the same will show the characteristic shapes of mycoderma cells.

FERMENTING POWER.

Besides the microscopical examination of the yeast it is also of great importance to determine the fermenting power of the same. This is done as follows: A quantity of the yeast is poured out on several layers of filter paper and allowed to dry fairly well. A solution is made of 40 grams of cane sugar (saccharose) with enough distilled water to make 400 c.c., five grams of the dried yeast weighed off and mixed with the sugar solution in a bottle. The bottle is now closed with a sulphuric acid bulb and weighed. It is then placed in a waterbath with a constant temperature of 86° F. for twenty-four hours, after which the bottle is weighed again. The loss in weight, caused by the escape of carbonic acid gas, gives the fermenting

power of the yeast. A good brewers' yeast should develop least five grams of carbonic acid in twenty-four hours.

DETECTING CAUSES OF BEER TURBIDITIES.

Turbidities of beer can be caused by:

1. Yeasts (cultivated and wild yeasts and mycoderma)
2. Bacteria.
3. Albuminoids.
4. Starch.
5. Hop-resin.

YEAST TURBIDITY.

If the turbidity is due to yeast the intensity of the turbidity determined by counting the yeast cells by means of a hæmatim ter. The cells in the sixteen fields, each composed of twenty-fi small squares, are counted, and the number of cells thus obtain is multiplied by ten, giving the number of yeast cells contain in one cubic millimeter. The counting is repeated two or thr times, that is, two or three different preparations are made and t cells counted.

By means of the gypsum block culture we are enabled to d termine whether the beer is infected by wild yeast or not. T presence of mycoderma is proven if, after infecting a small qua tity of sterilized wort with the beer, a film is formed on the su face after the mixture has been standing two or three days ordinary temperature. This film must then be subjected microscopical examination, as other micro-organisms can al form films on beer or wort.

BACTERIA TURBIDITY.

In order to distinguish between bacteria and small particles albumen present in the beer, the latter is mixed with a fe drops of potassium hydrate solution and then slightly heate when the albuminoids will be dissolved. The bacteria are th counted by means of the hæmatimeter, as when counting yea cells.

One hundred to two hundred bacteria per cubic millimet make the beer hazy, while 500 or more make it more or le turbid.

ALBUMEN TURBIDITY.

This turbidity is best determined by the following method: After the beer has been well shaken, it is poured into two glass beakers of 100 c.c. capacity so that it stands about one to two inches high. One of the beakers is then warmed to about 88° F. and the heated beer compared with that in the other beaker. If it has become clear, the turbidity was caused by albumen.

Beer that has been steamed at too high a temperature, very often becomes turbid by albuminoids. This turbidity does not disappear on simply warming the beer. The addition of a few drops of potassium hydrate solution, followed by heating, will in most cases partly or entirely clarify the beer.

STARCH TURBIDITY.

The cause of this turbidity is readily found by the addition of a solution of iodine. A quantity of the beer is poured into a test tube and a few drops of iodine solution added. If starch is present, the beer will appear either blue or black, according to the quantity of starch it contains. If the beer contains erythro-dextrin, the liquid will become red or brown when iodine solution is added, according to the quantity.

HOP-RESIN TURBIDITY.

This turbidity is of rare occurrence. It can easily be detected in the following way: A quantity of the beer is poured into a small glass beaker, and a few drops of alcohol or ether added. The beer is then well stirred with a glass rod. If it becomes clear, the turbidity was due to hop-resin.

LUBRICANTS AND LUBRICATION.

The question of proper lubrication of the different machin
used in the brewery and malt-house, in fact, anywhere else, is
matter of no small importance.

The amount of power necessary to drive a machine, and th
means the coal pile, as well as the life and proper running
the machines, is greatly influenced by proper lubrication of tl
sliding surfaces or bearings.

Although it is, of course, good business policy to purchase
lubricating oil, etc., as cheaply as possible, nevertheless, th
striving for economy is apt to be carried too far, so that it h
in many instances become a "penny wise, pound foolish" polic
A high quality lubricant can be purchased only at a correspon
ingly high price.

A second mistake often made is to use one kind of lubrica
for too many purposes, thereby enabling the purchase of
larger quantity at one time. It is evident that a lubricant be
adapted for use on shafting or heavy slow running machines
not suitable for high speed light machinery.

Another error is the application of too much of the lubrica
to bearings that do not need it, or would not, if kept proper
adjusted. One often finds machinery literally "swimming in oil,
which is a wasteful proceeding, and should this excessive applica
tion be necessary in order to keep the bearings from heating, it
a reflection either upon the maker of the machine for accura
and material used, or upon the skill or care of the mechanic i
charge. An exception to this are tapping machines and certa
types of high speed machinery the bearings of which are lubr
cated upon the oil-bath principle, but here special construction
provided to prevent the oil from splashing about.

The proper construction of the bearings has also a great de
to do with economical lubrication since a properly adjusted bea

ing requires less oil and will retain it longer than a loosely constructed one, the latter allowing the oil to run out as fast as it is supplied.

A considerable aid to proper lubrication is given by the oil cups with adjustable feed now in use, by means of which the oil supply can be regulated, and several hours' supply filled at one time.

THEORY OF LUBRICATION.

If two substances are rubbed against one another their motion is retarded by what is called friction. The smoother the surfaces of these substances can be made, the less friction will there be. This friction is caused by the high points in the surface of the one sinking into the depressions in that of the other and thereby retarding their motion. A surface that may appear smooth to the eye is in reality quite rough, as can be seen if a piece of highly polished steel is examined under a magnifying glass or microscope. This friction, be it ever so small in the beginning, soon becomes greater in an ever increasing ratio. This is due to small particles of the substances being broken off, and the surfaces thereby roughened, the particles assisting in further abrasion or grinding. This can be illustrated by rubbing two pieces of glass together, when it will be found that at first they hardly make any impression upon one another, but if the rubbing is continued they will become "ground" or "frosted," and a layer of powdered glass will be formed between them.

ACTION OF LUBRICANTS.

If these surfaces moving past each other can be kept apart so that their high points or ridges cannot strike against each other, it is evident that there can be no abrasion or "wear and tear." This separation is accomplished by means of lubricants, that is, substances that are viscous or "sticky" enough not to be readily squeezed out from between the surfaces, and at the same time fluid enough not to retard the motion of the surfaces. These lubricants form a thin film between the surfaces and keep them apart while moving. The lubricant must, furthermore, be of such a nature as to have no action upon the material of which the moving parts consist, for if it contains acids the latter will attack metallic parts and be likely to cause the opposite result from the one desired.

ANTI-FRICTION METALS.

If the surfaces of two substances of equal hardness rub together it is likely that they will wear equally. If on the othe hand the substances are of different hardness, the softer will b the one that wears more. On this account one of the movin parts is generally made of a softer material, or, where the sam material is used for both, one is fitted or lined with a softer material that can be readily removed and replaced.

In modern machinery this softer material is a metal called anti friction metal, and is principally of two kinds: bearing metal consisting of an alloy of copper, tin and zinc, and babbitt metal made from tin, antimony and copper.

KINDS OF LUBRICANTS.

The lubricants, or their substitutes, now in most general us can be classed as follows:

1. Mineral oils.
2. Fixed oils and fats.
3. Blown or thickened oils.
4. Blended oils.
5. Resin (rosin) oil.
6. Lubricants, containing soap.
7. Greases.
8. Solid lubricants.

MINERAL OILS.

Crude petroleum is the source of the mineral lubricating oil now in general use. Some kinds of crude oil are used in practically their natural state for lubricating heavy bearings, but the bulk of the crude oil is subjected to distillation. This furnishes an almost endless number of different products.

These products are, however, not simple substances, but mixtures of different hydrocarbons, the boiling points of which are limited within narrow confines. Out of the different products obtained the following may be mentioned:

Cymogen.—A gas at ordinary temperature, used in the manufacture of ice.

Rhigolene.—Also a gas, used for medicinal purposes.

Petroleum Ether.—Liquid, boils at 160° to 190° F.; used as solvent for fatty oils, etc.

Gasoline.—Liquid, boils at 160° to 190° F.; used for oil extraction from seeds, etc.

Naphtha.—Liquid, boils at 176° to 250° F.; used for burning, and as a solvent for resins.

Ligroine.—Liquid, boils at 176° to 250° F.; used as a solvent.

Benzine.—Liquid, boils at 250° to 300° F.; used for cleansing and as a substitute for turpentine.

Kerosene or Burning Oil.—(Standard white, prime white and water white.) Used for burning in lamps; must stand "fire test," that is, it must not develop ignitable gases below a certain temperature (110° to 150° F.).

Lubricating Oils.—What remains of the natural oil after the removal of the above named substances by distillation is called residuum, and is used for the manufacture of lubricating oils, paraffine and vaseline.

Distilled Oils.—The residuum, after the removal of the lighter oils, is allowed to stand for some time, and then transferred to so-called "tar stills," in which the lubricating oils are distilled off by superheated steam or in vacuo. Oils produced in such manner are called distilled or paraffine oils. The first distillate furnishing light lubricating oil for light machinery is called "neutral oil," and is used for mixing with fixed oils. Upon further distillation the heavier oils called "spindle oil" and "engine oil" are obtained, and finally an oil distills over at about 600° F., which is used as "cylinder oil." What is now left behind is further treated and furnishes paraffine wax and vaseline. The distilled oils are then chemically treated for further purification and bleaching with dilute sulphuric acid, which is then removed by water and a solution of caustic soda.

To avoid decomposition by high heat the petroleum is preferably distilled with steam under high pressure or in vacuo. After the lighter oils have been driven out, and the volume reduced, the remaining black, viscous oil is also called "reduced oil," and is used for heavy machinery. It may contain tarry matter, which is objectionable. For the manufacture of cylinder oils special kinds of petroleum are used, which are carefully reduced at low temperature and in vacuo; the reduced oil is then filtered through animal charcoal repeatedly.

The removal of the light oils is sometimes carried out in open

shallow tanks, in which the oil is exposed to sunlight while floating upon water warmed by steam. Such oil is called "sunned oil."

A characteristic of nearly all mineral lubricating oils is their fluorescent appearance when contained in bottles or transparent vessels.

Shale Oil.—Crude shale, a substance similar to petroleum, found mostly in Europe, gives products similar to crude petroleum by which it is now mostly replaced.

Paraffine is found native as a fossil wax, and is contained in the least volatile part of petroleum residues, from which it is obtained by cooling to a low temperature. It is also largely made from bituminous shale.

Paraffine is a white, waxy substance, without taste or odor. It is insoluble in water and cold alcohol, soluble in petroleum ether, kerosene and warm fixed oils. It is not acted upon to any extent by acids or alkalies.

Vaseline or petroleum jelly is also prepared from the least volatile portions of petroleum. It is separated from the crystallizable paraffine, and purified. Vaseline is a pale, yellow, translucent substance. It finds some use as a lubricant, but its principal application is for medicinal purposes.

FIXED OILS.

These are so called on account of being fixed, that is, not volatile, or capable of being evaporated or distilled.

Fats.—Fixed oils and fats derived from animal and vegetable tissue are practically identical except in consistency, the fats being solid. Fats, however, become oils when heated, and fixed oils become fats when cooled.

Fixed oils and fats differ from mineral oils in their behavior toward oxygen. The former combine with it, thereby becoming thicker, even solid, while the mineral oils are inert toward oxygen.

Spontaneous Combustion.—This absorption of oxygen by fats and oils is accompanied by a rise in temperature, the more so, the larger the surface of the oil. Rags or machinist's waste saturated with oil present a large oxidizing surface and will, on this account, especially if inclosed in a box, etc., absorb oxygen so fast as to become ignited by what is generally termed spontaneous combustion.

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Mineral oils, as they have no affinity for oxygen, are not subject to spontaneous combustion, and when mixed with fixed oils reduce the liability to combustion in proportion to the amount present. This oxidizing or "drying" property renders some of the fixed oils unfit for lubrication, prominent among which is linseed oil, being on that account most useful as a paint oil. Those possessing this oxidizing property the least, and that are used, therefore, mostly as lubricants, are cottonseed, olive, castor and rape oil of the vegetable oils, and sperm, neatsfoot and lard oil, also tallow, among animal oils.

The mineral lubricating oils are not acted upon by caustic alkali, that is, do not saponify. Fixed oils can on that account be easily distinguished from them.

BLOWN OR THICKENED OILS.

These oils are manufactured by blowing a jet of air through heated fixed oils, principally cottonseed and rape oil. The oils thereby become thicker and more viscous. These oils are not used alone as lubricants, but mixed with mineral oils to increase the body or viscosity of the latter.

BLENDED OILS.

Mixed or blended oils consist of varying proportions of mineral and fixed oils mixed so as to be best adapted for the purpose for which they are to be used.

As mineral oils are cheaper than fixed oils, and as the latter are not suitable for every purpose, this mixing has the advantage of furnishing an oil that is better suited for many purposes than would either alone. As mineral oils are best adapted for high speed and light pressure moving parts, and fixed oils for slow speed and heavy pressure parts, the best results for intermediate speeds and pressures can, therefore, be obtained with properly mixed or blended oils. This mixing cannot, however, be always resorted to, as the solid hydrocarbons, paraffines, etc., contained in some mineral oils are precipitated by this mixing.

RESIN (ROSIN) OIL.

Resin oil is the product of destructive distillation of common resin. It is a viscid liquid of dark brown color, with a strong fluorescence. It contains a considerable proportion of unchanged resin, carried over by the oil. Its specific gravity is high, ranging from 0.96 to 0.99, and sometimes much higher. It is not

used by itself as a lubricant, but to some extent as an adulterant for other lubricants.

LUBRICANTS CONTAINING SOAP.

These are often used as a thickening medium for mineral oils. If enough soap is added a gelatinous grease is formed. The soap generally used is aluminum soap, made by saponifying various fixed oils with caustic soda and stirring this into a solution of alum. A precipitate of oleate of aluminum is thereby obtained which, after drying, etc., is added to the lubricant.

Aluminum soap has practically no lubricating quality and is therefore considered as an adulterant; in fact, it is claimed by some to decrease the efficiency of the lubricant. Regular soaps, made with oils and caustic soda alone, are also used, but mostly as an addition to oils to produce lubricating grease.

GREASES.

These nearly all have tallow as their base mixed with various oils, although various soaps are also used instead of the tallow.

Axle Grease.—This consists usually of resin grease prepared by treating resin oil with slaked lime, and stirring this into more resin oil, or with petroleum or coal tar oil.

SOLID LUBRICANTS.

These consist mostly of talcum or soapstone, and plumbago and graphite, the latter being the one almost exclusively used. Solid lubricants are used for very slow speeds and great pressures, and will remain in some bearings where grease or oil would run out. Solid lubricants are also used for lubricating link belting running over sprocket wheels, which, if lubricated with oil, would throw off or splash the oil by centrifugal force, or if running in dusty places gather grit, etc., which would cause undue wear.

OILS FOR HOT OR COLD USE.

Besides selecting oils best adapted for speeds or pressures, the temperature of the moving parts must also be considered.

Cold Test Oils.—These oils are used for lubrication of refrigerating machines, and must have the property of remaining liquid at temperatures of from 15° to 0° F. without congealing or solidifying.

Hot Test Oils.—Cylinder oils, used for lubricating piston and valves in the steam cylinder, must have the opposite property of

cold test oils, viz., they must remain viscous and not decompose at the high temperatures of pressure steam in the cylinder. Cylinder oils should have an evaporating or decomposing point much higher than the temperature at which used, this ranging from 500° to 600° F.

CHEMICAL AND PHYSICAL PROPERTIES OF LUBRICANTS.

The properties to be considered in judging the fitness of a lubricant are (see also "Brewers' Chemical Laboratory"):

1. Viscosity or "body" of the lubricant at the temperature at which it is used;
2. Temperature of solidifying or thickening point;
3. Flash point, the temperature at which the lubricant begins to give off inflammable vapors, which, however, are extinguished if flame is removed;
4. Fire test point, at which these vapors burn continuously;
5. Amount of volatile substances contained;
6. Drying, gumming or oxidizing property of the lubricant;
7. The proportion of admixtures of other fats or oils;
8. Acidity, effect on metal surfaces;
9. Mineral admixtures or adulterants.

LUBRICANTS FOR DIFFERENT PURPOSES (THURSTON).

Low temperatures, as rock drills, etc.—Light mineral lubricating oils.

Very great pressures, slow speed.—Graphite, soapstone (talcum) and other solid lubricants.

Heavy pressures, slow speed.—The above, and lard, tallow and other greases.

Heavy pressures, high speed.—Sperm oil, castor oil, heavy mineral oils.

Light pressures, high speed.—Sperm, refined petroleum, olive, rape, cottonseed oils.

Ordinary machinery.—Lard oil, tallow oil, heavy mineral oils, and the heavy vegetable oils.

Steam cylinders.—Heavy mineral oils, lard, tallow.

Watches and other delicate machinery.—Clarified sperm, neatsfoot, porpoise, olive and light lubricating oils.

For mixture with mineral oils, sperm oil is best, lard oil much used, and olive and cottonseed oils are good.

LEGAL RELATIONS OF THE BREWER

The legal relations of the brewer are more complicated tha those of most other manufacturers and merchants. He is subje not only to all the ordinary duties which are incumbent upc every inhabitant, but also to many special ones that are impose upon the manufacture of, and traffic in, intoxicating beverages l the Federal, State and Municipal governments, for purposes part of regulation, partly of taxation, and often for both purpose Inasmuch as the brewer quite frequently not only manufactur and sells to the consumer and retailer but is obliged to look aft the retail business and assume responsibility for the dispenser (his products, he is brought into constant and immediate conta with the operation of all the laws that affect the liquor traffic.

It is not intended here to give information as to the ordinai rights and obligations of the brewer as a manufacturer ar merchant, which he has in common with all other classes (business men, but only the extraordinary or special relatioi that connect him with the various governmental agencies as manufacturer of, and dealer in, intoxicating beverages. As f: as possible, the intricacies of legal phraseology will be avoide and the sense of the respective laws and regulations given in transcribed form so as to be readily intelligible to the non-leg mind.

TAXES PAYABLE TO THE UNITED STATES GOVERN MENT.

Under the Internal Revenue laws of the United States and tl executive regulations of the Internal Revenue office a gallon (beer, ale, porter or other fermented liquor means a measure co taining 231 cubic inches.

A brewer is every person who manufactures fermented liquo of any name or description, for sale, from malt, with or witho adjuncts.

THE STAMP TAX.

On all such fermented liquors a tax is levied which, beginning July 1, 1901, amounts to one dollar and sixty cents ($1.60) per barrel, flat, that is, there is no rebate on this amount. Parts and multiples of barrels pay proportionate amounts.

Accordingly, the tax on barrels, and fractions and multiples of barrels, beginning July 1, 1901, is:

One-eighth barrel	20 cents.
One-sixth barrel	26⅔ cents.
One-fourth barrel	40 cents.
One-third barrel	53⅓ cents.
One-half barrel	80 cents.
One barrel	$1.60
Two barrels (hogshead)	$3.20

Until June 30, 1901, the tax amounts to two dollars ($2.00) per barrel. Accordingly, the tax on barrels, and fractions and multiples of barrels, until June 30, 1901, is as follows:

One-eighth barrel	25 cents.
One-sixth barrel	33⅓ cents.
One-fourth barrel	50 cents.
One-third barrel	66⅔ cents.
One-half barrel	1 dollar.
One barrel	2 dollars.
Two barrels (one hogshead)	4 dollars.

On this tax there is allowed a discount of 7½ per cent which is deducted at the time the tax is paid to the collector.

The above are the fractional parts and multiple of one barrel authorized by law. If a package contains any substantial amount in excess of its nominal capacity, it pays tax for the next bigger fraction. Thus, a package containing more than one-eighth and less than one-sixth is accounted one-sixth.

The tax is paid by the purchase of stamps, which are issued by the Federal government and sold to brewers by the Collectors of Internal Revenue. In purchasing such stamps, the regulations of the Internal Revenue office must be strictly followed. Such instructions can be obtained in printed form from the collector of the district in which the brewer does business.

NOTICE BY BREWERS.

Following the natural order of procedure, the first step of a brewer starting out in business is to file with the collector

istrict where he intends to carry on his business a notice ıg the name of the person, firm or company, and of the bers of any such company or firm, their residences, a descrip- of the brewery premises, the title of the brewer thereto, and name of the owner of the land. In case of a corporation the ıes of the shareholders need not be given, but those of the offi- s. The notice is made out in duplicate on blanks which the lector's office will supply on request. This notice is repeated on ıy 1 of each succeeding year as long as the business is con- ıued. Bottling plants are not to be described in this notice. he notice must be signed by the brewer himself or an author- ed agent or attorney; in case of a partnership, by a member ıereof in the firm name, or other person authorized as before; n case of a corporation, under the seal and by the proper officer.

SPECIAL TAXES.

At the time when the above notice is filed, the brewer must pay the special brewer's tax, which is $100 a year, where he manufactures 500 barrels or more per year, and $50 where he manufactures less than 500 barrels per year.

Besides, if a brewer sells malt liquors not of his own manufacture, at retail, that is, in quantities less than five gallons at one time, he is subject to a retail dealer's tax of $20. If he sells such liquors at wholesale, that is, in quantities of five gallons or more, he is subject to a wholesale dealer's tax of $50. This does not apply where he purchases malt liquor from another brewer in his own casks upon giving the proper notice to the collector as elsewhere explained, but in that case the amount so purchased is included in calculating the liability to the special brewer's tax of both the manufacturer and the purchasing brewers, i. e., in determining whether they manufactured 500 barrels a year or less.

GIVING BOND.

When giving the notice of his intention to carry on the brewin business the brewer must give a bond in a sum equal to thr times the amount of tax, which, in the opinion of the collect the brewer is liable to pay during any one month. He must gi a new bond every four years or at any other time if the collec *requires it.* The bond is for the faithful performance of all *duties required* of him with reference to the tax. Blanks can

obtained from the collectors. The sureties on the bond must have no interest in the business.

BOOKS AND RETURNS.

Every brewer must keep a separate book in which is entered, from day to day, the kind of malt liquor produced, the estimated quantity produced, in barrels, and the actual quantity sold or removed for consumption or sale in barrels or fractional parts of barrels. A certain form of book is recommended for this purpose by the Internal Revenue office, and can be obtained from certain stationers.

In another book he must enter, from day to day, an account of all the materials purchased by him for the purpose of producing such fermented liquors, including grain and malt. Brewers must make apparent in this book the disposition made of all materials entered which are not used in the production of fermented liquors.

The entries in both these books, the beer book and the materials book, must be verified on or before the tenth day of each month, by the oath of the persons who made them, the oath to be written in the book at the end of such entries in the form prescribed in the instructions obtained from the collector. Where the owner, agent or superintendent did not himself make the entries, he must subjoin his oath to the truth of them, for which oath the form is also given in the instructions. The books must be open at all times for the inspection of the collector or his proper representative.

On or before the tenth day of each month the brewer must render to the collector, in duplicate, a statement taken from his books, of the estimated quantity, in barrels, of malt liquors brewed, and the actual quantity sold or removed for consumption or sale during the preceding month. This statement is to be verified by oath before the collector or his proper deputy. A certain blank is provided by the collector's office for these statements.

Fermented liquors removed without stamps to a warehouse in the district must be returned as part of the stock on hand at the brewery. Where such removal is to another district, such district must be stated; where to more than one district, the word "other" is inserted in the blank instead of the number of the district; and a voucher giving a detailed statement must accompany the report.

A brewer who sells at retail, besides affixing the tax stamps to the vessels, is required to keep an account of the quantity so sold, with the number and size of the vessels, and to make a monthly sworn report of such sales.

The report must be signed by the person by whom it is rendered, and if not verified by himself, he must cause it to be verified by some person having personal knowledge of the business and being otherwise fully qualified by his position to make the oath. This includes being fully empowered by the principal to verify the statement, which authority, in case of a corporation, should be conferred by resolution. The person verifying should append his title to his signature, as attorney, agent, etc.

OBTAINING AND AFFIXING THE STAMPS.

The brewer buys stamps as he expects to require them, from the collector of his district, and can secure them in another district only if the collector of his own district cannot deliver them to him.

Stamps can be delivered by the collector only upon the written order of the brewer made in a certain form, of which blanks will be supplied by the collector as required.

It is essential to have on hand stamps for all kinds of packages that are expected to be used, as only one stamp must be used on any one package, unless it is bigger than a hogshead. It is not allowed to use two or more stamps of smaller denomination to make up the value of one of larger denomination, as two quarters for one half-barrel, etc.

The re-use of stamps, that is, the use of one stamp more than once, is prohibited absolutely, and there is no exception to this rule. If packages returned to the brewery should still have the stamps on them, the brewer must destroy such stamps, no matter how they came to remain on the package.

The law requires that when a keg or other vessel of beer is removed from the brewery or warehouse (except under permit as elsewhere explained) the brewer shall affix the stamp denoting the requisite amount of tax upon the spigot-hole, in the head of the package, which stamp shall be destroyed by driving through the same the faucet through which the liquor is to be withdrawn, or an air faucet of equal size, at the time the vessel is tapped, in case the vessel is tapped through the other spigot-hole (of which there shall be but two, one in the head and one

in the side). Furthermore, the brewer shall at the time of affixing such stamp cancel the same by writing or imprinting thereon the name of the person, firm or corporation by whom the liquor was made, or the initial letters thereof, and the date when canceled.

If a brewer sells at retail at the brewery he must affix and cancel the proper stamps on the vessels, and keep an account of the quantity so sold and the number and size of vessels in which it was contained and make a monthly sworn report thereof to the collector.

These provisions make it necessary that the stamps should be well secured to the vessels, and not easily removed therefrom except by intentional effort for that purpose. The following method of preparing and affixing them is therefore recommended:

Dissolve one pound of chloride of sodium (common salt) in two gallons of cold water; spread this over the backs of the sheets of stamps with a broad, thin brush, and then dry them. They are now ready to be affixed. In applying the stamp to the cask, first take liquid silicate of soda of medium density; rub it well into the irregularities of the surface of the wood with a brush, and apply the stamp *quickly* while the wood is quite wet. When the stamp is dry, a second coating of the silicate should be spread over the face of the stamp; and if the barrels are to be exposed to the action of the weather, or to be stored in damp places for considerable periods, the stamp should be secured by four tacks to prevent its peeling off.

In renewing the stamp upon a barrel used a second time, the tacks should be withdrawn and the stamp carefully scraped off.

REMOVAL TO WAREHOUSE.

In order to remove malt liquor from the brewery to a warehouse or depot or other place of storage, permits must be obtained from the collector of the district where the brewery is located, and the tax stamps need not be affixed until the liquor leaves such warehouse. Lager beer may be so removed in quantities not less than six barrels in one vessel, and ale or porter or other malt liquor, fifty barrels. The permits are required to be affixed to the vessels in which the liquor is removed.

Application for such permits is made on certain blanks prescribed by the Internal Revenue office, and when the permits are delivered, a receipt in certain form is given by the brewer.

The brewer, upon receiving the permits, will at once securi affix them to the heads of the barrels near the chime and immed ately under the bung stave. At the time the permit is affixed will cancel it by writing or stamping across the face thereof l name, the location of his brewery, and the date of the cancellati of the permit. As soon as the permits are affixed and within fi days after their delivery to the brewer, he will notify the collect of the fact, in order that the collector may record the date affixing, on the stubs of such permits retained in his offi Dates on these permits should be written or stamped with gre distinctness. If the packages are too long on their way, they m be detained and the brewer required to prove absence of fraud lent intent.

If the warehouse is in another district the brewer must prompt notify the collector of the latter district of the receipt of t liquor at such warehouse, such collector having been previous notified of its removal by the collector of the district in whi the brewery is located.

The permits must remain on the packages until they are r moved from the warehouse and the tax stamps affixed, when t permits must be scraped off and destroyed. Tax stamps are o tained from the collector in whose district the warehouse is l cated. All liquor so removed to other collection districts is e tered in their books and reported in the monthly returns.

SOUR OR DAMAGED LIQUOR.

If liquor has become sour or damaged so as to be incapat of use as a beverage, it may be sold for manufacturing purpos and removed from the brewery in vessels unlike those ordinari used for fermented liquors, containing not less than one barr each, and having the nature of their contents marked upon the without affixing the permit or stamp.

BOTTLING BEER.

Beer cannot be bottled in the brewery. A separate bottli building must be provided which is separated from the brewe by a public thoroughfare and has no communication with t brewery. However, this bottling plant may be connected wi the brewery by a pipe for the purpose of running the beer to bottled through it. If there is no such pipe connection, the be must be filled into stamped packages and taken across the ro into the bottling department. Bottling fermented liquor fro

open and unstamped vessels is not permitted; neither is the addition of water, fermenting agents, extracts, etc., allowed previous to bottling. The steaming, washing and storage of bottles on brewery premises is not permitted.

If a brewer wants to run a pipe line from the brewery to his bottling plant for the purpose of running bottle beer through it, he must proceed in a certain prescribed way. He must give a supplemental notice to the collector in duplicate on blanks provided by the collector, containing among other things an estimate of how often beer will be thus removed to the bottling house. The bottling house must be just as distinct from the brewery as where the beer is removed in a stamped packages.

The brewer must construct a measuring cask or tank in the brewery for the bottle beer, admitting of ready measurement and having a capacity equal to the amount of liquor to be removed for bottling in twenty-four hours. More than one such cistern may be authorized by the collector, if necessary, to supply the bottling house for twenty-four hours, and none must have a capacity of less than ten barrels. The tank is required to be securely covered, and if an opening is desired, it must be so arranged that it can be securely locked. A glass gauge must be attached in order to observe the level of the liquor in the tank. Stop-cocks must be provided to control the flow into, and out of, the measuring tank, and must be capable of being locked. No such tank can be used until after it has been examined by a deputy collector and he has attached his certificate thereto. The vessel and its attachments may be examined at any time by Internal Revenue officers.

The pipe, or conduit, must be securely connected with the measuring tank in the brewery. No opening is permitted in the pipe line.

The measuring tank may, if preferred, be placed in the bottling house. In that case the pipe line which is to carry the beer to the bottling shop can be placed underground only by running it through a tunnel of sufficient size to admit the convenient passage through its entire length of the revenue officer, who is required to examine the pipe line. The pipe must be so placed as to admit of ready examination at any point. Each measuring tank must have a separate supply pipe.

Before a pipe connection to the bottle shop can be used, a plan and description of the plant in triplicate must be prepared on good

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paper or tracing linen, 15x20 inches in size, one to be posted in the brewery, one kept by the collector, and one to be sent to the Commissioner of Internal Revenue. This plan must show in detail the exact location of all vessels, conduits, casks or implements used in the transfer of the liquor; also the capacity of the measuring tank, the course of the pipe and the thoroughfares crossed by it, the boundary line of the brewery premises, and the nature of the business conducted in all buildings located within ten feet of the pipe line. Any alterations in any of the parts required to be shown must be displayed by a supplemental plan.

To avoid needless trouble and expense it is best always to submit such plans in advance to the collector of the district, who will examine and certify them, if found correct.

The stop-cock controlling the inflow of liquor into the measuring tank on the brewery premises, and the opening in the top of the tank, if any, are secured by padlocks, and the stop-cock controlling the outlet into the pipe by a seal lock. Locks and seals are supplied by the collector. If the measuring tank stands in the bottling house, the inflow cock is controlled by a seal lock as well as the outlet. These two cocks must never be unlocked at the same time, but either may be opened as suits the convenience of the brewer.

When the brewer wants to send beer to the bottling house, he makes application to the collector or his proper deputy, on a form prescribed by the Internal Revenue office, stating the amount to be transferred, which must be enough to supply the bottling house for at least twenty-four hours, and never less than ten barrels at one time. Request is also made for the attendance of a deputy collector.

The deputy collector, after locking the supply pipe of the measuring tank in the brewery and the opening in the top, if any, noting the quantity in the tank and observing that the proper seal is in the lock at the junction with the pipe line, will remove the seal lock from the latter, enabling the brewer to open the stop-cock. After the liquor desired to be sent to the bottling house has entered the pipe, the deputy collector closes the stop-cock and secures it by the lock, first inserting the proper seal. He then unlocks the supply cock of the tank and the opening in the top, if any, and leaves them open until the next lot of liquor is sent to the bottling house.

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The brewer must then present to the deputy collector the number and value of tax stamps corresponding to the amount of liquor withdrawn from the tank, having previously written or printed on the margin of such stamps the name of the brewer, firm, or corporation, or the initials, and the date of the transfer of the liquor. The deputy collector cancels the stamps by a die or punch and transmits them to the collector of the district.

The brewer must report the amount of liquor transferred to the bottling house and the number and denominations of stamps used, in his monthly report, in a separate item.

Where the measuring tank is located upon the bottling premises, the stamps must be canceled upon the entire quantity of liquor in the cistern before any of it is withdrawn therefrom.

If it is necessary to connect any of the apparatus in the bottling house with the refrigerating machine or air pump in the brewery, the pipes making such connection must be exposed to view for their entire length and subject to ready examination by revenue officers at all times. All such additional appliances must be exhibited in the plans submitted to the collector.

MARKING CASKS.

Every brewer must brand all his trade packages before removal from the brewery, with his or the firm's or corporation's name and place of manufacture.

If he purchases liquor from another brewer, he may, upon previous written notice to the collector in a form prescribed by the Internal Revenue office, furnish his own vessels branded as though for his own beer, and have them filled by the manufacturer, who must affix and cancel the proper stamps. The manufacturer enters such beer in his beer book and makes a special entry of it in his monthly return to the collector, as "sold at brewery at wholesale." The purchaser also enters it in his beer book, together with the stamps affixed by the manufacturer, and when the beer is sold, makes a footnote in his monthly report in the form prescribed by the department. These special entries are required to be made in red ink.

TO CARRY ON BUSINESS AT ANOTHER PLACE.

If by reason of accident by fire or flood, or the brewery undergoing repairs, or other cause which is sufficient in the opinion of the collector of the district, a brewer desires to carry on his business temporarily at another place in the same or an ad-

joining district, he must apply to the collector for a permit, which is issued for a certain time, and the brewer need not pay another special tax. Consent to such temporary change must be indorsed on the brewer's bond by his sureties.

SELLING WORT.

If a brewer sells unfermented wort to another brewer for the purpose of being used in producing fermentation or enlivening fermented liquors, he must obtain a permit for the removal of such wort from the collector of his district and remove such wort within the time specified and the regulations prescribed. The stamp tax is paid by the purchasing brewer on the finished liquor produced by the admixture of such wort. Brewers should, if possible, use for such purposes, vessels unlike those ordinarily used for fermented liquors, containing not less than one barrel each and having the nature of their contents marked upon them.

PENALTIES.

Failure to make correct entry and report of fermented liquors as required by law, or attempt to evade the payment of the tax on them, failure to do any of the things required by law to be done in this connection, or making false entries or reports is punishable by forfeiture of all the liquors made and all the vessels, utensils, and apparatus used, also by a fine of $500 to $1,000 and imprisonment for not to exceed one year.

Neglect to keep books as required by law, refusal to furnish the required amounts and duplicates, or refusal to allow the proper officer to examine the books, is punishable by a fine of $300.

Refusal or neglect to affix and cancel the tax stamps required by law, or the affixing of a false or fraudulent stamp, is punishable by a fine of $100 for each package and imprisonment up to one year.

Fermented liquor found after removal from the brewery or warehouse, except upon permit, without payment of the tax required, is liable to seizure and forfeiture. The absence of proper stamps in such cases is notice to all persons that the tax has not been paid, and is prima facie evidence of the non-payment thereof.

Where liquor is removed under permit and without stamps, the permits must be affixed, canceled and destroyed as prescribed by the Internal Revenue office, under the same penalties as provided to stamps.

Withdrawing fermented liquor from any unstamped package for the purpose of bottling, or carrying on the business of bottling fermented liquor in any brewery, or premises having communication with the brewery, or any warehouse, except as provided for bottling houses, is punishable by fine of $500, and the property used is liable to forfeiture. The same penalties apply to the violation of any of the regulations in regard to bottling.

Anyone who removes, or connives at the removal of, fermented liquor through a pipe line without the payment of the tax, or who attempts to defraud the revenue in any manner in connection with such business, is liable to forfeiture of all the liquors made by and for him, and all vessels, utensils and apparatus used in making them.

Defacing or removing the marks branded on trade packages, except by the owner or authorized agent, is punishable by a fine of $50 for each package.

Refusal or neglect to affix and cancel the stamps required by law, and affixing a false or fraudulent stamp, is punishable by a fine of $100 for each package and imprisonment for not more than one year.

The removal, sale, receipt, or purchase of fermented liquor in an unstamped package, or package not having the proper permit, or having a false or fraudulent stamp or permit, with knowledge that it is such, or of a package on which a canceled stamp is used a second time, is punishable by fine of $100 and imprisonment for not more than one year.

Withdrawing fermented liquor from (or tapping) any package without destroying or defacing the stamp, or from an unstamped package, or a package fraudulently stamped, is punishable by a fine of $100 and imprisonment for not more than one year.

Selling, making or using any counterfeit stamp, permit or die for making counterfeit stamps or permits, or removing a stamp for the purpose of re-using, or re-using any stamp, or receiving, buying, selling or giving away, or having in one's possession any fraudulent stamp, is punishable by fine of $100 to $1,000 and imprisonment for from six months to three years.

Removing or defacing a stamp or permit on any package containing fermented liquor, except by the purchaser or owner or his agent, is punishable by fine of $50 for each package and creates a liability in damages to the owner.

EXPORTING FERMENTED LIQUOR IN BOND.

The system of allowing rebates of tax on beer exported been abandoned. The present system provides for exporting bond, the brewer giving a bond to the Collector of Internal Re nue providing for the payment of double the amount of tax on liquor in regard to which the regulations are not observed. T bond must be for not less than double the amount of tax on estimated quantity of liquor to be exported during three mont and in no case less than $1,000.

In case of direct exportation in original packages from brewery, or transfer to a bottling plant for export, stamps w coupons are issued by the collector. The brewer affixes to e package directly over the spigot-hole, the export stamp with requisite number of coupons, so that the last coupon on the sta will correspond to the size of the package. Thus one barrel have the stamp with six coupons attached. The end of the sta not pasted on is fastened to the package by tacks. Where liquor is transferred to a bottling establishment such stamps m be destroyed by driving a spigot or air faucet through at time the liquor is drawn off. The stamps must be so affixed as admit of a spigot being driven through without injury to serial number and denomination of the attached coupons to removed by the bottler.

If fermented liquor is to be conveyed to a bottling establi ment by a pipe line, the brewer must notify the collector, who send a deputy to supervise the transfer, which is made as wh the beer is not intended for export. The brewer and bottler m each keep a memorandum of the quantity of liquor transfer with the date of transfer.

The collector issues export labels to the bottler in books 200 each, the stubs being returned to the collector when the b has been used up. The liquor must be bottled not more t forty-eight hours after its arrival in the bottle shop, the bot keeping a memorandum of each lot bottled, giving quantity ceived, name of brewer, number and size of packages with port stamps, date when packages were tapped and prices of exp stamps removed, number and size of bottles, and number contents of cases in which bottles have been placed with numb of export labels.

In drawing from the original package the bottler must drive

[redacted]

faucet through which the liquor is drawn, or an air faucet, through the brewer's export stamp, and detach the undestroyed part of the export stamp from the package and forward it to the collector. Each lot of liquor must be kept separate, as it must be accounted for separately. The liquor must be cased for export within twenty-four hours and securely fastened, and each case have the export label affixed with the requisite number of coupons showing the quantity, in gallons, contained in each case. Where the quantity is not in even gallons, and the fractional part is less than one-half, it is excluded from the quantity represented in the export labels, the discrepancies thus arising being adjusted in the bottler's monthly statement to the collector.

On the first day of each month the brewer who has removed fermented liquor, and the bottler who has received such liquor, makes a monthly declaration, under oath, in duplicate to the collector as to such liquor so removed and received, the form of such decalaration being obtained from the collector. Each day's transactions are reported separately in the proper column.

Fermented liquor to be exported may be entered for export in any outward port or at any frontier port, or at an interior port for transshipment to an outward or frontier port, or when it is to go through a frontier port in sealed cars over bonded routes, it may be entered at any port from which such cars clear for export. In any case, the exporter must, six hours before shipment, file with the Collector of Customs (not the Collector of Internal Revenue) an export entry in the form to be obtained at the collector's office. This entry may be made by an agent having a power of attorney from the exporter, if the latter does not live at the place of entry. The exporter must also file with the Collector of Customs a bill of lading.

If the articles are entered at any port for exportation through another port, the exporter must state in his entry the routes over which they are to be shipped. In case of shipment through frontier ports in sealed cars, the exporter may apply to the collector of the port of entry to have the goods locked and sealed. In the latter case, a transportation manifest and through bill of lading must be filed.

If from any cause the required proofs cannot be furnished or regulations complied with application for relief must be made *to the Collector of* Internal Revenue who has cognizance of the *facts.*

TONICS, ETC.

The war revenue law of 1898 provides for a tax on medicinal proprietary articles and preparations, among which are tonics, and all medicinal preparations or compounds which are held out or recommended to the public by the makers, vendors or proprietors as proprietary medicines or medicinal proprietary articles or preparations, or as remedies or specifics for any disease, diseases or affection whatever affecting the human or animal body. This tax is as follows: Where the retail price or value of the package is five cents or less, one-eighth of a cent; where the retail price or value is 5 to 10 cents, two-eighths of a cent; where the retail price or value is 10 to 15 cents, three-eighths of a cent; where the retail price or value is 15 to 25 cents, five-eighths of a cent, and for each additional twenty-five cents or fractional part thereof, five-eighths of a cent.

The law further provides in regard to such articles that this stamp tax shall apply to all medicinal articles . . . . which are . . . advertised on the package or otherwise as remedies or specifics for any ailment or as having any special claim to merit, or to any peculiar advantage in mode of preparation, quality, use or effect.

The Internal Revenue office holds malt extracts and similar preparations, which are advertised as tonics, or held out as having a tonic or other medicinal effect, to be subject to this tax, and imposes it upon the tonics and similar beverages sold by brewers in such a way as to create the impression that they are desirable for their medicinal properties. Where they are not so advertised or named, they are not subject to this tax.

A decision given in February, 1901, by the United States District Court at Kansas City, Mo., holds that an article taxed as beer cannot be taxed once more as a tonic, and the claim of a brewing company for rebate of the tax paid on a tonic manufactured by them was allowed. The question has not yet been finally determined, however, and for the present the ruling of the Internal Revenue office stands.

If tonics or preparations of this character are represented to the public as medicinal preparations, and are in fact medicinal preparations, and are so sold by druggists or other retailers in good faith, such druggists or retailers do not require a retail liquor dealer's license from the United States government. But

if such compounds are sold as beverages, the druggists are subject to the regulations of retail liquor dealers, notwithstanding the fact that the compound may be used as a medicine and was so intended by the manufacturer. It follows that the mere addition of a medicinal drug does not of itself take the sale of the compound out of the regulations for retail liquor dealers.

WHAT IS INTOXICATING LIQUOR?

There is a prevalent misapprehension as to the term "intoxicating" liquor or beverage, and the attitude of the United States government with reference thereto.

As far as the Internal Revenue taxes are concerned, it makes absolutely no difference whether a fermented beverage is intoxicating or not. It may contain 1, or 2, or 6 per cent of alcohol or any other amount. The question is only whether it is a malt liquor or fermented beverage. If so, it is liable to the stamp tax, and the dealers are liable to the wholesale or retail dealers' license fees, as the case may be, and tonics are subject to the additional stamp tax for medicinal preparations.

The question assumes an entirely different aspect with reference to local regulations, that is, state laws and municipal ordinances regulating, restricting, or prohibiting the liquor traffic. Here the question whether a beverage is intoxicating or not, is generally paramount. The matter depends on the wording of local laws.

As a rule, the question whether liquor is intoxicating or not, is a question of fact to be determined in court by the jury, or judge in the absence of a jury. In some cases beer is presumed to be intoxicating and need not be shown to be so, as in Indiana, Kansas, Minnesota, Massachusetts (?). In some instances, the percentage of alcohol that a beverage may contain without being intoxicating is fixed by law or ordinance at 2 per cent. In most cases, the intoxicating quality of the beverage is a matter of evidence in each case.

If a brewer wants to put on the market a "temperance beer" for sale in prohibition districts, the local laws of the particular state or district should be looked up.

LIQUOR LAWS OF THE STATES AND TERRITORI

ALABAMA.

There is no general local option law, but by special act sale of liquor is prohibited in many localities, and elections on question provided in others.

License fees under the general law are as follows: Retail sell on boats and railroad cars, $250; in places under 1,000 inhabita $150; between 1,000 and 3,000, $200; between 3,000 and 10,($275; more than 10,000, $325; dealers in lager beer only, o fourth of the above rates; wholesale dealers, compounders ; rectifiers, $200; distillers (not of fruit), $25; brewers, $100; bo ing alleys, billiard tables, dice boxes, etc., all require license.

Fines up to $1,000 are imposed for selling to an appren without written consent of the master; to minors without c sent of parent, guardian or physician; to intemperate or ins persons; for selling without license; selling within one mile c church or a place of religious worship; permitting the use premises for illegal sale; selling on Sunday or election day; m ing or selling adulterated liquors; employing minors to liquors.

ARIZONA.

Boards of trustees of cities, towns and villages have autho to license, regulate or prohibit the sale of liquor. Quart license fees are payable as follows: Selling in quantities of t gallons and upwards, where quarterly sales amount to $20,(and upward, $125; sales of $12,000 to $20,000, fee $100; sales der $12,000, fee $75; in quantities of one pint to two quarts, $30; quantities less than one gallon in cities, towns or villages of and more population, $50; 200 to 800 population, $40; less tl 200 population, $20; at wayside houses, $12; distilleries and bre eries doing a business of $10,000 and upwards. $40; $5,000 to $1 000, fee $20; less than $5,000, fee $10. Local authorities may i pose additional license fees.

Fines up to $300 are imposed for the following offenses: S ing to a common drunkard or minor; keeping open on Sunda selling liquor without a license or refusing to exhibit license proper officer on demand; selling to an Indian; permitting min to remain in a place where liquors are sold; selling liquor wi out a license.

ARKANSAS.

High license and local option prevail in this state. The question of license or no license is submitted at a general election and covers a period of two years. If a majority of the adult inhabitants, including females, within three miles of any schoolhouse, academy or institution of learning, shall petition the county court, such court may make an order prohibiting the sale of liquor for two years. Prohibition is also in force in some districts by special act of the legislature.

If license is voted, the license is issued by the county court in rural districts and by the municipal authorities in incorporated municipalities. License fees are: Retail, $500 county tax and $300 state tax; wholesale malt liquors, $50 state tax, and $100 county tax. Municipal licenses are in addition to state taxes. The licensee also pays two per cent of the taxes as collector's fees, and $2 for clerk's fees. He must give a bond of $2,000 to pay all damages caused by reason of liquor sold in his house, and all money lost by gaming on his premises. Debts for liquor cannot be recovered. Wines from grapes and other fruits sold by the maker are exempt.

Fines are imposed up to $500 for furnishing liquor to students in any incorporated institution of learning; selling liquor within one mile of a camp meeting, except by regularly licensed tavern keeper or grocer at their regular place of business; selling liquor on election day or Sunday; allowing minors to play games in any dramshop or saloon; selling to minors without the written consent of parent or guardian; minor purchasing liquor without informing the dealer of his or her minority; allowing gaming, quarreling, fighting or disorderly conduct; selling to a soldier of the United States army without consent of an officer; selling without license, except in original packages of not less than five gallons; selling liquor in prohibition districts; selling without a license; shipping C. O. D. without the label: "This package contains intoxicating liquors"; keeping a "blind tiger" or similar device; a member of a club purchasing liquor for the use of members.

Any person making wine from fruit grown by himself may sell it in quantities not less than one quart without a license, and licensed liquor dealers may sell wine, except in localities where the *sale is prohibited* by law.

CALIFORNIA.

Under the constitution, any county, city, town or township ma make and enforce within its limits all such local police, sanitar and other regulations as are not in conflict with general law: There is no general law regulating the retail liquor traffic. Eac community accordingly regulates the traffic to suit itself, subjec to the following license fees for the sale of liquor in quantitie not less than one quart (wholesale): Monthly sales of $100,00 or more, $50 per month; monthly sales of $75,000 to $100,00 $37.50 per month; and so on through eleven classes to monthl sales less than $1,250, $1 per month.

There are fines provided up to $1,000 and in some cases im prisonment for the following offenses: Selling liquor withi one and one-half miles from the grounds of any asylum for dis abled volunteer soldiers or sailors, etc.; selling to a minor unde 18 years or permitting him to visit a place where liquor is sol for the purpose of engaging in games of chance; furnishin liquor to a person addicted to the inordinate use of liquor afte notice that the person is so addicted; selling anything but pur wine by that or similar names; allowing the sale of liquors in th state capitol; carrying on business without a license; selling to a habitual drunkard; fraudulently adulterating or diluting liquor selling liquor to anyone under the age of 16; employing female in saloons; selling within one mile of a religious field meeting selling liquor in any place of public amusement; selling at o within one mile (or two miles in one case) of certain public in stitutions; selling on election day. Selling to an Indian is made felony.

The regulations of the traffic differ widely in different part of the state. In the city of San Francisco a retail dealer i licensed by the board of police commissioners and if they ar not favorably disposed he must get the written recommendatio of twelve citizens owning real estate in the block or square wher the business is to be carried on. Dealers selling $15,000 worth an over per quarter pay $41 per quarter; those selling less, pay $21 Physicians and druggists do not require a license, but must no sell by the glass or to be consumed on the premises.

Bar rooms must be closed from midnight to 6 a. m. Liquor mus not be sold to minors under 18 years, and minors must no enter saloons upon penalty of $100 to $300 fine. Public drunk enness is a misdemeanor. Any violation of the regulations i de a misdemeanor.

COLORADO.

This state has a general license law, the fees being fixed at not less than $600 a year in cities, $500 in towns and $300 elsewhere; one-half this amount may be required for a license to sell malt liquor only. Licenses are issued by the municipal authorities of cities and towns, elsewhere by the county commissioners. The authorities may license, regulate or prohibit the liquor traffic. The cities of Colorado Springs and Greeley are under prohibition by virtue of covenants in the deeds from the original proprietors of the sites. Licensees must give a bond of $2,000. Liquor dealers are liable in damages for injuries from selling liquor producing intoxication only in the case of selling to drunkards after notice not to do so.

Fines up to $1,000 are provided for the following offenses: Selling adulterated liquor, or liquor branded or marked otherwise than to indicate its true character; importing into the state any adulterated liquor, or offering for sale any liquor, unless the package shows the name and address of the manufacturer; keeping open on Sunday or election day; selling without a license; selling to an Indian; to an habitual drunkard, knowing him to be such; to United States soldiers or state militia, within three miles of a camp of the latter; allowing minors around the place or selling to them, unless accompanied by parent or guardian; selling within a mile of a worshipping congregation, except at regular places; selling within five miles of any camp or assembly engaged in the construction or repair of a railroad, canal, reservoir, public work, etc., except in municipalities that have been established six months prior to the beginning of such work; keeping a saloon into which any female is allowed to enter; keeping open from midnight to 6 a, m.

CONNECTICUT.

License and local option prevails. Each town votes whether to have license or not. If it decides to have license, a board of three county commissioners issues the licenses. Application for a license is in writing, indorsed by five legal voters and taxpayers, none of whom is a licenseholder or applicant, or indorser on any other application for license. The application is published for two weeks, and any citizen may file objections. The applicant is required to show that he is a suitable person. If the license is granted the applicant must supply a bond wit

a surety, who is not a liquor dealer, in the sum of $300. No surety can go on more than one bond. If the licensee proves an unsuitable person or violates the law, the commissioners may revoke the license. A licensee convicted of a violation of the law forfeits his license and cannot take another for a year. The license fee to sell liquor is $100 to $500. Druggists may use liquor in prescriptions and sell them on the prescription of a practicing physician, but no druggist may sell liquor to be drunk on the premises. The law prohibits sales of liquor on Sunday, on election day, after midnight, to minors, to intoxicated persons, to habitual drunkards, to a man after notice from his wife not to sell to him, or to a woman after similar notice from her husband. Search and seizure of liquors unlawfully kept is provided for, also civil liability in case of injury by intoxicated persons.

DELAWARE.

Licenses are issued by the clerk of the peace, on approval of the application by the court of general sessions, the application having been previously filed with a certificate of twelve (in Wilmington, twenty-four) citizens, and published three times in two newspapers. Any retailer or druggist of good character, whose stock is of the value of $500, may be licensed. Druggist must sell in quantities not greater than a quart; other traders, half a gallon. No liquor must be sold on Sunday or election day, or to minors, insane persons or drunkards. Penalties are $50 to $100 for the first offense; forfeiture and disqualification for two years on second offense. Licenses are not personal, but restricted to certain premises of which the applicant is the owner. Judgments for violation of the law form liens on the premises. Druggist limited to sales of $75 a year. All manufactured liquors pay a tax of 10 cents a gallon. Relatives of known drunkards may recover actual and exemplary damages from persons selling them liquor, in case of accident. License fees are: In towns over 10,000 inhabitants, $300; elsewhere, $200; druggists, $20; retailers of merchandise, $100. No blinds, screens or frosted glass are allowed under penalties of $50 to $100.

DISTRICT OF COLUMBIA.

Licenses are issued by an excise board of three commissioners. Applicants must be 21 years of age and never have been convicted of a violation of the liquor laws or of gambling. In the cities of Washington and Georgetown the application must have

the written permission of a majority of the residents and owners of real estate on the side of the square on which the proposed bar room is to be placed, and if on a corner, a majority on both streets must approve. Outside of these cities consent must be had of a majority of residents and owners within 250 feet on each side.

Hotels having 20 chambers for guests need not make annual application for renewal of license, but during good behavior pay only the fee. Minors under 16 years must not be served or employed on licensed premises. Sale of liquor is prohibited on Sunday and from 12 to 4 a. m. Fee for wholesale license is $250, for a bar room, $500. Druggists may sell only upon prescription.

Penalties for selling without a license are: First offense, $250 to $800, with or without imprisonment for two to six months; second offense, the same fines, with imprisonment from three to twelve months.

For violation of conditions of license the penalties are: First offense, fine of $50 to $200, and for every subsequent offense, 25 per cent of the previous fine added, or imprisonment for six months, or until the fine is paid. No license can be granted after a second conviction. Penalty for aiding or abetting any violation of a license is a fine of $50 to $100, or imprisonment for one month. No place can be licensed within 400 feet of a schoolhouse or church.

FLORIDA.

License, with local option, is the law. Local option elections are held in election districts. Where the sale of liquor is permitted, licenses are issued by city and town councils. Before obtaining a license a permit must be obtained from the board of county commissioners. There are fines of $50 to $500 for selling from 6 p. m. preceding an election day until 6 a. m. the day after, selling without a license or permit, selling in a prohibition district, to a minor or an intoxicated person, within five miles of any religious camp-ground except in incorporated cities or towns by regular dealers, selling on Sunday, and selling any unwholesome drink.

GEORGIA.

High license and local option prevails. Where, by vote, the sale of liquor is not prohibited, the general state law regulating the *traffic applies.* Licenses are granted or refused by the

ordinary of the county. The licensee takes an oath not to sell to a minor without consent of parent or guardian, and gives a bond of $500 to keep an orderly house. The county retail license fee is $25. Liquors are inspected by an officer appointed by the ordinary. Selling without license, on Sunday, and the usual run of offenses, are prohibited. Where, in prohibition districts, the sale of certain kinds of wine is permitted, dealers in such wine, who are not manufacturers, pay a license fee of $1,000, and such wines are sold in quantities not less than one quart, and not to be drunk on the premises. The sale of liquor within three miles of any church or schoolhouse is prohibited, except in incorporated towns and cities, and except for domestic wines, for physicians and for manufacturers, selling to authorized dealers in packages of not less than 40 gallons.

A local option election is held on the written request of 10 per cent of the voters of a county, not oftener than every two years, and must be a separate election, not to be held within one month of any general election. Cider and domestic wines, and wine for sacramental use, and pure alcohol, sold by druggists for useful purposes, are generally excepted.

License fees vary greatly. The city of Atlanta has three licenses: One wholesale, for the sale of liquors of all kinds in quantities of one gallon or more, $25; retail, for consumption on the premises, $1,000; retail, for malt liquors only, $250. The fee may be as high as $2,000 for a retail license.

The licensee gives a bond of $2,000. Licensed premises must be closed from 10 p. m. till 5 a. m. No obstructions to view from the street are allowed.

Conviction of offense against the license law works a forfeiture of the license. Penalty for drunkenness is a fine up to $100 or imprisonment for 30 days, or both.

There is a dispensary law in existence, which, however, has been adopted only in the city of Athens.

IDAHO.

High license is the law of this state. The county authorities have power to issue licenses after a bond for $1,000 has been furnished to keep an orderly house, obey the law and pay all fines and damages. Incorporated cities and towns may impose additional license fees and conditions. Any town or city which cast 150 votes for governor at the last preceding election must require

$500 license; other places, $300. Bona fide hotels, three miles outside cities, towns or villages, pay only $100. Licenses for liquor, not to be drunk on the premises, are $200. The mayor and common council of Boise City have power to license and tax the retail trade. Damages may be recovered from liquor dealers for selling to habitual drunkards or minors, after notice not to do so. Druggists may sell liquor on the written prescription of a physician, and may sell wine for sacramental purposes, and alcohol for mechanical and scientific purposes, without a license.

Fines up to $500 are imposed for keeping open on the day of any general election; selling liquor to a minor; druggist selling liquor to be drunk on the premises; keeping a disorderly house; selling to an intoxicated person; selling without a license; selling to an habitual drunkard, after notice from justice of the peace or judge of probate not to furnish liquor to such person; selling to an Indian; fraudulently adulterating or diluting liquor; selling liquors within one mile of any religious meeting.

ILLINOIS.

License and local option prevails. A vote on the question of license or no license must be taken upon the request of a majority of the voters in any district or municipality. If license is favored by the vote, city councils and boards of trustees in towns and villages have power to regulate and prohibit the liquor traffic. The license fee is not less than $500; for selling malt liquors only it is $150. Outside of cities and villages licenses are issued by the county board, who cannot, however, issue any for places within two miles of any incorporated city, town or village, the authorities of which have the power to regulate the liquor traffic. Druggists may receive permits to sell for medicinal, mechanical, sacramental and chemical purposes only.

A dramshop is defined as a place where liquors are retailed in quantities of less than one gallon.

In the city of Chicago, by special provision, licenses are granted by the mayor to persons of good character who give bond in $500, with two sureties, to comply with all city ordinances. Places must be closed from 12 to 5 a. m. The license may be revoked by the mayor for violation of ordinances or conditions of bond. Licenses are payable in quarterly instalments.

Fines of $5 to $100 are provided: For selling liquors within *two miles of any* agricultural, horticultural or mechanical fair

or within one mile of religious camp-meeting; for keeping open on Sunday; for selling without a license; for selling to minors without written order of parent, guardian or family physician, or to habitual drunkards. All acts forbidden by law, when no other penalty is imposed, are made misdemeanors, punishable by fine up to $100.

Liquor sellers are liable in damages for any injury anyone may sustain in person, property or means of support by reason of the sale or giving away of intoxicating liquor.

INDIANA.

High license and a modified form of local option prevails. Petitions for licenses must be signed by a majority of the voters in the township or ward, and a bond of $3,000 given, with the penalty of forfeiture of the license for violation of the act, and disqualification for five years. A remonstrant against a license has the right of appeal from the grant of a license. In cities of more than 35,000 inhabitants licenses are granted by the common councils; elsewhere by the county boards. The state fees are: For selling liquors, $100; for selling vinous and malt liquors, $50. Cities may charge up to $250 additional; incorporated towns up to $50 additional. The licensing power extends four miles from the corporate limits. Places where intoxicating liquors are sold in violation of law may be abated as public nuisances. The licensee must give bond in $2,000 to secure the payment of fines and civil damages.

Fines of $10 to $500 are provided for adulterating wine, grape juice or intoxicating liquor, or selling such adulterated articles; for using any active poison in the manufacture of liquors, or selling liquors so prepared; for selling to an intoxicated person, or one in the habit of getting intoxicated, after written notice of such fact from any citizen of the place where such person resides; for selling to minors; for keeping a disorderly house; for selling on Sunday, legal holidays, election day, or between 11 p. m. and 5 a. m.; for a druggist selling liquor otherwise than on a physician's prescription; for selling liquor in booths, etc., within one mile of religious gathering or agricultural fair, not to apply to regular dealers at their usual place of business. Common councils may impose fines up to $500 for any violation of an ordinance, and may tax breweries and distilleries and their depots or agencies.

The so-called Nicholson law provides fines of $10 to $100 for violating any of the following provisions: Liquor selling in quantities of less than one quart must be carried on in a room separate from any other business; no amusements, music, etc., are permitted, no screens are allowed. The room must be locked during hours when liquor selling is prohibited, and all persons excluded therefrom. It must be situated on the ground floor or basement fronting the street, and so arranged that the whole of the room is in view from the street. Minors are not allowed to loiter in saloon, and no liquor must be sold to them. If a remonstrance in writing is filed, signed by a majority of the legal voters of any township or ward, against the retail sale of liquor by any applicant for a license, the board of county commissioners are prohibited from granting a license to such persons for two years from the filing of such remonstrance.

INDIAN TERRITORY.

The introduction of spirituous liquors or wine, except such supplies as may be necessary for the United States troops, under the direction of the War Department, is prohibited; also the selling to an Indian. Officers of the Indian service and commanders of military posts may seize any liquors introduced. The penalty for violation is imprisonment up to two years and a fine up to $300.

IOWA.

The manufacture and sale of any intoxicating liquor, or keeping the same for sale as a beverage is prohibited by the constitution. This prohibition is enforced by a number of acts of the legislature.

The so-called Mulct Law provides for a tax of $600 a year upon persons other than pharmacists holding permits, who engage in selling liquor. In any city of 5,000 inhabitants or over, after a written statement of consent signed by a majority of the voters in the city shall have been filed with the county auditor, the tax may be paid quarterly in advance, and such payment shall be a bar to proceedings under the statute prohibiting the liquor traffic upon the following conditions:

The taxpayer must file with the county auditor a copy of a resolution passed by the city council, consenting to the sale of liquor, and a written statement of consent from all freeholders owning property within 50 feet of the premises where the business *is to be carried on,* no such business to be conducted within 300

feet of any church or schoolhouse. The taxpayer must file bond. Business must be carried on in a single room, with h one entrance or exit opening upon a public business street; t room must have the bar in plain sight from the street, it mu have no furniture except behind the bar; the names of all en ployes must be filed with the county auditor. The place must conducted in a quiet and orderly manner, there must be gambling, music, dancing or other forms of entertainment in t room or in any adjoining room or building, if controlled by t same party. There must be no obscene or impure decoratio no females must be employed. The place must be kept clos between 10 p. m. and 5 a. m., also on Sundays, election days legal holidays. Minors, drunkards, or intoxicated persons mu not be allowed in the place and no liquor be sold to them to any person who has taken any of the recognized cures f drunkenness. Liquor must not be sold to any one after notice fro relative or guardian. The liquor dealer must report his place the county auditor if it has not been listed for taxation.

If these conditions are violated, the bar to proceedings und the prohibitory laws ceases to operate, if the city council or tov trustees direct it, or a petition signed by a majority of the vote request it.

In order to bring cities and towns of less than 5,000 inhabitan within this act, it is necessary, in addition to all the above ma ters, to file with the county auditor a written statement of co sent signed by 65 per cent of the voters in the county and outsi the limits of the cities having a population of 5,000 and over.

Cities and towns have power to collect additional taxes of t same character and to regulate the liquor traffic.

The law is not to be construed as legalizing the liquor traff nor the tax to be construed as a license, nor to protect the viol tors of prohibitory laws from any penalties except that certa penalties are suspended upon the conditions above enumerated.

The so-called Manufacturers' Law permits the manufacture intoxicating liquors in communities which have adopted t Mulct Law, provided that a written statement of consent is o tained from one-half the voters in cities and towns having a po ulation of over 5,000, and from 65 per cent of the voters in oth communities.

There are fines up to $1,000 for selling within 160 rods of a

[redacted]

agricultural fair; manufacturing or selling liquor of any kind except as above outlined; selling to a minor, intoxicated person or one in the habit of becoming intoxicated; carriers transporting liquor without certificate of the county auditor that the consignee is authorized to sell liquor; selling on election days or within two miles of the limits of any municipal corporation; druggist selling liquor as a beverage; selling within three miles of the state agricultural college; or within one mile of a religious field meeting; adulterating liquors or selling adulterated liquors; selling to an Indian or an intoxicated person; keeping a club room with liquor for members or others.

Druggists may obtain permits to sell for pharmaceutical or medicinal, sacramental or chemical purposes.

Buildings where liquor is unlawfully sold are declared nuisances and may be abated; all movable property in them is to be seized and sold.

KANSAS.

Constitutional prohibition of the manufacture and sale of intoxicating liquors, except for medicinal, scientific and mechanical purposes, is the fundamental law. The laws that have been enacted in regard to the matter contain but a long list of penalties for violations or evasions of the organic law.

Druggists can obtain permits to sell liquor from the probate judge of the county for a fee of $5. They can sell only on prescription or upon the purchaser's affidavit setting forth the purpose for which the liquor is required. The affidavits are kept on file and delivered to the probate court. Druggists are fined $100 to $500 for violating any one of numerous regulations with which the sale of liquor by them is surrounded.

The manufacture of liquors for medicinal, scientific or mechanical purposes is allowed upon permit issued by the probate judge, to be sold only in the original package. A person may make wine or cider from fruit grown by himself and for his own use, and wine may be sold for communion purposes.

All places where liquor is unlawfully sold are declared common nuisances and may be summarily suppressed.

Fines are provided for selling or giving away liquor under a great many different circumstances. Physicians are fined for prescribing or administering liquor, except in case of actual need, or for the purpose of enabling any person to evade any provision of law.

KENTUCKY.

High license and local option prevails. Elections are held in any county, city, town, district or precinct, upon the petition of 25 per cent of the voters, to decide whether or not any intoxicating liquor shall be sold, not oftener than once in three years. Where no license is voted, this does not prohibit manufacturers or wholesale dealers selling in good faith and in the usual course of trade, in quantities not less than five gallons, not to be drunk on the premises. Licenses may be imposed by the municipal authorities on distillers, brewers and wholesale dealers, besides retailers.

License fees, outside of incorporated cities and towns, are: To keep a tavern, with privilege of selling malt liquors, $50; the same, with retailing spirituous and vinous liquors, $100; the same, with retailing spirituous, vinous and malt liquors, $150; to retail malt liquors, $50; to retail spirituous and vinous liquors, $100; to retail spirituous, vinous and malt liquors, $150; to distillers, at their place of business, not less than one quart, not to be drunk on the premises, $75; manufacturers of vinous liquors and peach and apple brandy, $25; merchants, to retail in quantities not less than one gallon, not to be drunk on the premises, $75; druggists, in quantities not less than one quart, not to be drunk on the premises, and on prescription for medicinal purposes in less quantities, $50. Retail licenses in cities of the first class, $150 to $1,000; in cities of the second class, $50 to $150; in cities of the third, fourth and fifth classes, $250 to $1,000; in cities of the sixth class, $150 to $500. Outside of cities and incorporated towns the county board issues licenses.

Fines up to $500 are imposed for adulterating anything intended for drink; keeping open on Sunday or election day; selling without a license; selling within one mile of a place of divine worship; selling to a minor without written directions from parent or guardian; selling to an inebriated person; selling in a room where pool-tables, etc., are kept; knowingly selling liquors adulterated with any injurious drug or chemical preparation; druggists failing to keep register as required, or selling otherwise than on prescription; selling from a temporary place within two miles of any militia encampment; violations of city ordinances; allowing gaming; keeping a disorderly house. Municipal authorities have power to regulate the traffic and impose other fines.

Special provisions are made for regulating distilleries.

LOUISIANA.

The liquor traffic is taxed in accordance with the extent and character of the business. Besides a retail license, which must be not less than $100 per annum, taxes are levied on the business of distilling and rectifying alcoholic or malt liquors, brewing ale, beer, porter, or other malt liquors, according to the gross annual receipts. There are twenty classes, the tax being graded accordingly. Where the gross annual receipts are $2,250,000 or more, the tax is $3,000; for $2,000,000 or more, $2,500, and so on by different stages to the twentieth class, which comprises houses with gross annual receipts less than $15,000, on which the tax is $15. For every business of bar room, cabaret, coffee-house, cafe, beer saloon, liquor exchange, drinking saloon, grogshop, beer-house, beer garden, or other place where anything to be drunk on the premises is sold, the license is based on the gross annual receipts, as follows: Receipts, $50,000 or more, fee $1,500; thence down to $100 for receipts of $3,000 to $5,000. Municipal and parochial authorities may impose fees and equitable graded licenses.

The following offenses are punishable by fines up to $1,000: Selling liquor on election day; keeping a disorderly house; selling to persons under 21 years, unless emancipated, or upon order of parent or tutor; selling to habitual drunkard, after proper notice that he is an inebriate; employing any female; physician prescribing with intent to evade the law; for selling liquor on Sunday; selling without a license; not posting the license in a conspicuous place.

Concert saloons require the consent of a majority of the property holders and residents within a radius of 300 feet from the front door, and must not keep open from 5 a. m. to 6 p. m.

Hotels and boarding houses may furnish wine for table use on Sunday.

Police juries of the parishes, the municipal authorities of the several towns and cities, and the city council of New Orleans have exclusive power to regulate or prohibit intoxicating liquors and to grant or withhold licenses according as a majority of the voters may determine by ballot, elections to be held on this question whenever deemed necessary by the municipal authorities, not oftener than once a year.

MAINE.

A prohibition state. A constitutional amendment authorizes the governor and council to appoint a commissioner to furnish municipal officers of towns with pure liquors, to be kept and sold for medicinal, mechanical and manufacturing purposes. Prices are to be at a profit of 6 per cent above cost. The municipal officers are allowed to buy liquor from no one but the commissioner or persons to whom he has sold. The commissioner is required to keep a record of the towns to which liquors are sold, the persons buying, the kind, quantity and prices. The municipalities appoint agents for the sale of liquor in their respective towns, who also keep full records. The manufacture of liquors, except cider, is prohibited under penalty of $1,000. No liquor is allowed to be sold, except through the agencies, and fines are provided for officials violating the law. Places where unlawful sales take place are declared public nuisances, liquor unlawfully kept may be confiscated and the person keeping it imprisoned and fined $100.

Fine of $5 to $20 for selling or giving liquor to an Indian; for unlawfully keeping or selling liquor and keeping resorts for tippling, $100 to $1,000; for soliciting or taking an order for the sale or delivery of liquors, $20 to $500; for bringing into, or transporting within the state liquor to be sold unlawfully, $50 to $100; carriers transporting liquor, up to $200; for selling liquor in violation of law, $50 for first offense and $200 for every subsequent offense; for being a common seller of liquors, $100 for first, and $200 for subsequent, offenses; for selling unwholesome drink or adulterating, up to $1,000; for offenses "for which no punishment is provided by statute," up to $500; for advertising sale, or keeping for sale, of liquor, $20.

MARYLAND.

No general law prevails, different localities being legislated for separately. In a general way the prevailing system is one of license.

An act for the city of Baltimore provides for a licensing board of three commissioners, appointed by the governor. License may be granted to any citizen of temperate habits and good moral character. The application must be supported by ten voters in the ward, published and publicly heard, if opposed, after which the vote of the commissioners on the question must be recorded.

The board is bound to refuse a license if the place is not necessary for the accommodation of the public or the applicant is not a fit person. Violation of a state law relating to the sale of liquor is required to be followed by revocation of the license. The fee is $250 for hotels, restaurants, grocers, distillers, brewers or wholesale dealers, one-quarter going to the state, the balance to the city. Sale of liquor is prohibited on election day and Sunday, except to guests in hotels, also between the hours of midnight and 5 a. m. Druggists may sell upon written prescription and must keep a record of sales.

Penalties for selling liquor without a license, $500 to $5,000, or imprisonment for three to twelve months; for violation of law or conditions of a license, fine of $100 to $500; for a second offense the license is revoked and a fine of $500 to $1,000 imposed, and the offender may also be punished by imprisonment for three to twelve months.

MASSACHUSETTS.

A general license law, coupled with local option, prevails. The question of license or no license is submitted to a vote in each city or town annually. If the vote is in the negative, no license can be granted, except to druggists for medicinal purposes. There are six classes of licenses, each valid for a year: (1) To sell liquor of any kind to be drunk on the premises, minimum fee, $1,000; (2) malt liquors, ciders and light wines containing not to exceed 15 per cent of alcohol, to be drunk on the premises, minimum fee, $250; (3) malt liquors and ciders, to be drunk on the premises, minimum fee, $250; (4) liquors of any kind, not to be drunk on the premises, minimum fee, $300; (5) malt liquors, ciders or light wines, not to be drunk on the premises, minimum fee, $150; (6) druggists, for any kind of liquor for medicinal, mechanical and chemical purposes only, upon certificate of the purchaser, fee, $1. No sales are allowed from midnight to 6 a. m. or on Sunday, except by innkeepers; liquors must be good and unadulterated; no liquor must be sold to drunkards, intoxicated persons or minors; no disturbance of the peace, indecency or illegal gaming is allowed on the premises. Where liquors are sold, not to be drunk on the premises, no public bar shall be kept, and a license as innkeeper or common victualer must be obtained. A bond of $1,000 is required. Penalties for violation of the conditions of licenses are $50 to $500, or imprisonment for

one to six months, or both, besides forfeiture of license and prohibition from securing another for one year. Fines are provided for selling to minors, etc. Licensing officers may enter licensed premises at any time to observe the conduct of business, or obtain samples for analysis. A state inspector and assayer of liquors is to analyze all samples sent to him by the proper authorities. Search for liquors unlawfully kept, and their seizure, when found, is provided for, also the arrest and detention of intoxicated persons until they disclose the places where they obtained the liquor.

Screens or other obstructions of view of the interior of a place where liquor is sold are prohibited.

Fines for violating any provision of a license, $50 to $500.

Special club licenses for a fee of $50 to $500 may be issued in towns where liquor licenses are granted. Elsewhere such clubs are to be deemed common nuisances, and fines of $50 to $100, for keeping them, are assessed.

Intoxicating liquor means all beverages containing more than 1 per cent of alcohol.

No licenses of the first three classes shall be issued for a place on the same street within 400 feet of a public school.

Additional fines: Fifty to $100 for common victualer keeping open between 12 and 5 a. m.; $50 for dispensing liquors on election day, except innkeepers may sell to duly registered guests; $50 to $100 for selling liquor under the first three licenses on legal holidays, or election day; for selling liquor to be drunk on premises, employing anyone under 18 years of age.

The number of places licensed under the first five classes shall not exceed one for each 1,000 of population, except in Boston, where the ratio may be one to 500. Towns having an increased population in summer may grant special licenses, in force from June 1 to October 1, at the ratio of one to 500, based on an enumeration in June.

MICHIGAN.

License and local option is the law. The board of supervisors of a county must order an election on the question of prohibiting the liquor traffic, not oftener than every two years, upon the petition of one-fourth of the electors of the county, and if the vote is in favor of prohibition, the board must issue an order accordingly.

Where the sale of liquor is permitted, license fees are imposed as follows: For retailing all kinds of liquor, $500; for malt liquor only, wholesale and retail, $300; for spirituous liquors, wholesale, $500; for the same, wholesale and retail, $800; for brewers, $65; for manufacturing spirituous liquors, $800. Retailing means selling by the drink, in quantities of three gallons or less, or one dozen quart bottles or less. Druggists may sell without license for chemical, scientific, medicinal, mechanical or sacramental purposes.

The sale of liquor in places of amusement is prohibited. Fines up to $500 are assessed for selling liquor to inmates of the soldiers' home; for selling to drunkards, tipplers or disorderly persons; for selling to minors, except for medicinal or mechanical purposes, without the written order of parent or guardian, to a drunken person, to a person in the habit of getting intoxicated, to an Indian, or a person of Indian descent, to anyone, when forbidden to do so in writing by the husband, parent, wife, child, guardian, employer, supervisor, mayor, director of the poor, supervisor or alderman, etc.; to any person to be used as a beverage, or to be drunk on the premises; for any violation of the liquor law not otherwise provided for; to sell to students at any public or private institution of learning, or allow them to play billiards or games of chance in a place where liquor is sold; for allowing a minor to visit or remain in a room where liquors are sold, unaccompanied by his father or guardian; for keeping open on Sunday, on election days, on legal holidays, and until 7 a. m. the day after, between the hours of 9 p. m. and 7 a. m., except in cities and incorporated villages the time of keeping open may be extended to 11 p. m.; for obstructing the view of the interior of premises where liquor is sold during the time when such places are required to be closed; for selling liquor at summer homes, camp-meetings, etc.

The adulteration of liquors with any articles poisonous or injurious to health or knowingly selling such liquor, as well as selling liquor from any barrel, etc., not branded with the name of the manufacturer and with the words, "Pure and without drugs or poison" is prohibited. Violations are punishable by fine of $50 to $500, as is also the "manufacturing, brewing, distilling, selling or having or offering for sale, any liquors containing any substance not normal or *healthful*, or deleterious or detrimental to health."

The usual civil liability is imposed by statute on liquor dealers for any injuries resulting from the intoxication of a person, and the dealer's bond of $3,000 to $6,000 is available to secure such damages, as well as fines for violations of the law.

MINNESOTA.

High license and local option prevails. Local option is provided for villages and for counties, but not for cities. A vote is taken on the petition of ten or more voters at the next ensuing annual election. If license is favored, the general license law becomes applicable, otherwise the sale of liquor is prohibited.

Applications for license are published and objections to them heard by the village, county or city authorities, and if the applicant has violated any liquor law within a year, the license must be refused. The licensee gives a bond of $2,000. City councils have power to tax, license and regulate breweries and distilleries.

The license fees are $1,000 or upwards, as the city council may prescribe, in cities of 10,000 and upwards; elsewhere $500 or upwards. Druggists may sell on medical prescription without license. Physicians who prescribe to evade the law are subject to fine. All places where liquor is sold must be closed from 11 p. m. to 5 a. m., except hotels. Violation of this rule is followed by forfeiture of the license, and fine. The licensing authorities may revoke the license for violation of any of the liquor laws or conditions of the license. If a license is revoked for selling to a minor or drunkard after notice not to sell, the offender is disqualified for five years from holding a license. In other cases, revocation disqualifies for one year. Conviction of selling to a minor, to an habitual drunkard or intemperate person after notice forfeits the license. All convictions of violations of the license law are certified by the court to the licensing authorities. No license shall be issued within 1,500 feet of any public school in localities outside of incorporated cities, villages and boroughs.

Penalties are up to $300 for keeping open on election day; for selling at retail without license or off the premises described in the license; selling to a minor; to a student at any institution of learning; to an habitual drunkard or intemperate drinker, or an intoxicated person; keeping open on Sunday; selling to In-

dians; selling in the state capitol grounds during sessions of the legislature; selling within one mile of the state fair grounds, or within half a mile of Hamline University, or one mile of the University of Minnesota, or two miles of a religious meeting, except regular licensees; selling between 11 p. m. and 5 a. m.; for allowing any game except billiards and pool or allowing minors to play at dice, cards, billiards or pool; selling without a license; operating a "blind pig" or "hole in the wall;" for druggist allowing liquor to be drunk on the premises; for selling liquor in a prohibition district.

In the city of Minneapolis the so-called "patrol limit act" prevails. It limits licensed places to a certain territory, which is practically the business portion of the city, and applies equally to hotels as to dramshops.

MISSISSIPPI.

License and local option prevails. Elections on the questions of prohibiting the liquor traffic may be held not oftener than every two years. No retail license shall be granted in any supervisor's district, city, town, or village if the majority of the voters have petitioned the authorities not to grant such license, within twelve months after such petition is presented. Where license is permitted, the corporate authorities of cities, towns and villages may grant licenses for the sum of $600 to $2,500. Outside of such municipalities the boards of county supervisors issue licenses for a fee of not less than $600. Besides, the following taxes are imposed by the state: Bottling establishments $20, breweries $150, dealers in hop tea, hoppenweis and similar drinks $25; dealers in vinous or spiritous liquors in quantities of 1 to 5 gallons, $300; the same in quantities of 5 gallons or more, $100; wholesale liquor dealers in cities of 5,000 or more inhabitants, $100; the same in cities of 2,000 to 5,000, $50; the same elsewhere, $25; distilleries, $50. Retailers may sell at wholesale. In the Yazoo-Mississippi delta district retail dealers pay $100; bottlers $10.

Fines up to $1,000 are imposed for selling liquor within two miles of any place of religious worship except regular licensed dealers at their regular places of business; keeping open on Sunday or election day; selling without license; keeping disorderly house; allowing gaming; selling to intoxicated persons; to persons in the habit of getting intoxicated; to Indians

and to minors; landlords allowing tenants to sell unlawfu selling in prohibition districts; selling at places of amusem or public assemblages; putting up screens or other devices to c ceal the interior of the place; selling within five miles of state university.

Any person may sell wine made of grapes grown by h self in any quantity not less than one gallon, at the reside or vineyard of the seller, to a sober person who is not in habit of becoming intoxicated, without license, but this does apply where an election has resulted against the sale of liqu

MISSOURI.

High license and local option is the prevailing system. election to decide whether or not liquor shall be sold m be held upon the application of one-tenth of the voters in incorporated city or town with a population of more than 2,5 or a like proportion in a county exclusive of such cities or tow The election must not be held within three months of any oth If the vote is against liquor, the sale of it is prohibited un penalties of $300 to $1,000 fines or imprisonment for 6 to months, or both. An exception is made in favor of wine the sacrament and alcohol for medicinal, mechanical, artistic, a scientific purposes. A local option election cannot be held ofte than once in four years.

Where liquor is allowed to be sold the retail limit is th gallons, and liquor dealers must have licenses. Application a license is made to the county court and must be supported a city or town of 2,500 or over by a majority of the taxpay in the same block, elsewhere by a majority of the taxpayers the city, town or township and also on the block. The petiti must be renewed every year. The court may grant or ref the license, and if the petition is signed by two-thirds of the t payers and the applicant is of good character, it must be grant Every six months the licensee gives a sworn statement of quantity and value of all liquors received by him and pays there an ad valorem tax equal to that paid by merchants on merchandi He gives a bond of $2,000 for obedience to the law. The licer fees are semi-annual and at the following rate: For state pu poses $50 to $200, for county purposes $250 to $400. Local a thorities may impose an additional tax. In cities the may

and assembly have power to regulate the liquor traffic; retail license fees must be not less than $750.

Fines up to $1,000 are provided for keeping booths, tents, etc., within one mile of any religious field meeting; for keeping open on Sunday or general election day; selling to Indians, intoxicated persons, habitual drunkards; selling without a license; druggists selling in quantities less than four gallons, except on written prescription of a physician or for art, mechanical and scientific purposes, failing to keep a record of sales in the proper way, or suffering liquor to be drunk at or about his place of business; selling by peddlers, or on carts, carriages or boats; knowingly selling to a student of the state university or any school, college or academy; selling to minors or having a minor play at any game without written permission of parent, master or guardian; selling intoxicating liquors to be drunk on the premises where made; selling to an inebriate after notice from a relative not to do so; having any music, billiard or other game or allowing such to be carried on in the premises. Forfeiture of license with disqualification for two years may follow for selling on Sunday. Forfeiture must be ordered for keeping a disorderly house.

The selling of any unwholesome drink without making its nature known to the purchaser is fined up to $1,000. To manufacture or sell any ale or beer containing any substitute for "hops, pure extract of hops, pure barley malt, or wholesome yeast" is punishable by fine from $500 to $5,000. All beer is required to be inspected by state inspectors, and a tax of one cent a gallon for inspection and two cents for labeling each package, except on beer exported from the state, is levied.

In the city of St. Louis a list of all licensees is furnished the controller twice a month and the police report on all dramshops. Obscene and immoral pictures are prohibited. No woman reputed to be immoral is allowed to be employed as bartender or waiter or to sing or dance in an improper manner. Saloons are prohibited within 500 feet of the five principal parks. Three citizens may make a sworn complaint to the mayor of a disorderly saloon, the mayor must cite the keeper before him, and if convinced of the truth of the complaint must revoke the license. Licenses cannot be transferred.

MONTANA.

License and local option prevails. Upon the petition of o third of the voters of any county an election is held to ‹ termine whether liquors shall be sold, such election to be h not oftener than once in two years. If the vote is in favor the sale of liquor, licenses must be procured from the cou treasurer, and in cities and towns another one from the muni pality. The licenses for retailing, that is, selling liquor quantities less than one quart, are for six months; in citi towns, villages and camps with a population of 10,000 and ov and within one mile therefrom, $300; the same of 3,500 to 1 000, $250; the same 1,000 to 3,500, $240; the same 300 to 1,0 $200; the same under 300, or elsewhere, $150. Licenses are 1 transferable. Wholesale licenses are determined by the avera monthly sales as follows: For sales of $100,000 or more, $ per month; $75,000 to $100,000, $60; $50,000 to $75,000, $40; $4 000 to $50,000, $25; $30,000 to $40,000, $20; $20,000 to $30,0 $15; $10,000 to $20,000, $12; $5,000 to $10,000, $8; $2,500 $5,000, $5; $1,250 to $2,500, $4; $400 to $1,250, $3; less than $4 $1. Brewers or sellers of malt liquors in quantities of more thai gallons, pay licenses according to their monthly sales as follow Sales of $3,000 or more, $50; $1,000 to $3,000, $25; $500 $1,000, $12.50; less than $500, $7.50. Distillers, manufactur and rectifiers of spirituous liquors pay a license of $600 per ye Manufacturers of malt who do not make malt liquors pay $1.c per quarter. City and town councils have power to issue censes in addition, not to exceed the amounts of the state licens

Fines are provided up to $500 for selling where the liqu traffic is prohibited; selling without a license; selling on electi day while the polls are open; selling liquor in any theater other place of amusement, or employing a female to sell liqu in such a place; selling within one mile of any camp meetir except at regular licensed places; adulterating or diluting liqu with fraudulent intent; selling within two miles of any railro in the course of construction, except in cities or towns.

NEBRASKA.

High license with local option by counties prevails. T *licensing* authorities are the county commissioners, except *Omaha*, where the board of fire and police commissioners pe

form this function; in Lincoln, where an excise board exists; in other cities, the city council; in incorporated villages, the board of trustees. Application is made with the approval of a majority of the freeholders of the town or precinct, and if objection is made, a hearing must be appointed. The authorities may refuse all applications, and must do so if the applicant has had a former license revoked or violated the liquor law within a year.

The license fees are not less than $1,000 in cities with a population of 10,000 or over, and not less than $500 elsewhere. The licensee gives a bond of $5,000. No one may be surety on more than one bond. Druggists may get permits without fee to sell liquor for medicinal, mechanical or chemical purposes. Licensees must keep doors and windows unobstructed.

The civil liability of the licensee extends to all damage sustained by the community or individuals from his traffic. He must support paupers, widows and orphans who become so by intemperance from liquor supplied by him, and pay all expenses of civil or criminal prosecutions growing out of, or justly attributed to, his traffic.

Fines up to $1,000 are imposed for the following offenses: Selling within forty rods of an agricultural fair; selling without license; violating any excise rule prescribed by the proper authorities; selling to minors, apprentices, insane persons or habitual drunkards; selling to Indians who are not citizens; selling liquor on election days or Sundays; druggists failing to keep the required records of all sales; for "treating or giving any liquors" in any saloon or public place where they are kept for sale; within three miles of open air religious meetings, except regular licensed places.

Persons may, without a license, sell wine made from grapes grown by them in the state. A fine of up to $100 is provided for putting adulterated liquor into a vessel having a mark of a maker of wine from grapes in the state, for the purpose of deceiving a person; also selling liquors adulterated with poisonous ingredients or any other substance.

NEVADA.

Licenses are issued by the county commissioners who have authority to license, tax, regulate or prohibit dramshops, etc., and in unincorporated cities and towns to levy a tax upon wholesale

liquor merchants, brewers, manufacturers of liquors and bee saloons, bars, barrooms, cellars, etc. License fees for sale in quan tities not less than one quart are as follows per month: For sale of $100,000 or more in a month, $50 per month; sales $75,000 t $100,000, fee $37.50; $50,000 to $75,000, fee $25; and so o down to $1,000 a month or less, fee $2.50. Retail licenses (les than one quart) are at the rate of $10 a month, unless in hotel located one mile from any city or town, when $15 is paid Peddlers, etc., pay $25 a month. To conduct a hurdy-gurdy house, dance house, concert saloon, etc., $500 every three month in addition to the retail license. Traveling agents pay $200 a year. Wine or liquors produced from the agricultural product of the state may be sold by the manufacturer, and liquors used by druggists and physicians in the preparation of medicines.

Fines run up to $1,000 and are for the following offenses Doing business without a license; selling on election day; vio lating municipal ordinances; keeping a booth for selling liquo within one mile of any religious meeting; knowingly sellin poisonous or adulterated liquors; selling to a minor or menta imbecile without an order from parent or guardian, or to a Indian; failure to keep the license posted in a conspicuous place keeping or renting a saloon with an entrance on a principa street where liquors are served by females; keeping open be tween midnight and 6 a. m., except hotels.

NEW HAMPSHIRE.

Prohibition prevails. The sale of liquor, including beer, i prohibited by law, not by the constitution. The manufacture o liquor, however, is not prohibited, and breweries and distillerie exist. The governor appoints an agent for the exclusive sale o liquors for use in the arts and for medicinal, mechanical, chem ical and religious purposes only. Sales are made to town agent appointed by the municipalities. Domestic wine or cider is no prohibited, nor the sale of spirituous liquors imported into th state and sold in the original packages. Municipal officers ar liable to fine for failure to prosecute for violations of the law Other persons prosecuting violators receive one-half of the fin collected. Persons arrested for drunkenness will not be pun ished if they disclose the persons from whom they procured th liquor and testify against them. Groceries, stores, restaurant

and places of amusement may be searched for liquors, and all liquor found and instruments used in their manufacture and sale in violation of law, seized and forfeited.

Selling spirituous liquor by persons other than authorized agents entails a fine of $50 for first offense and $100 for subsequent offenses; $100 fine for a common seller of spirituous liquor; likewise $10 and $50 for selling malt liquor or cider; for soliciting or taking orders for liquors, $50 and $100; for bringing liquor into the state for unlawful use, $50; for wilfully letting any person use one's premises for the illegal sale of liquors, $200; for furnishing liquor to a minor, pauper, spendthrift or idle person under guardianship, except by permission of guardian, up to $20; for adulterating liquors with any substance poisonous or injurious to health, or selling them, up to $1,000. Liquors kept in violation of law may be seized and forfeited.

NEW JERSEY.

License and local option prevails, the question whether licenses shall be issued being decided not by vote of the electors but by the authorities of each municipality. The law authorizes each municipality to regulate the liquor traffic in its jurisdiction and to appropriate to its own use all the fees received from licenses. There is, therefore, no uniformity in the regulation or taxation of the traffic.

NEW MEXICO.

City councils and boards of trustees in towns have authority to license, regulate or prohibit the sale of liquors. Minimum fees are: Wholesale license, $100; brewers', $60; distillers', $200; retailers' in places up to 500 inhabitants, $100; 500 to 1,000, $200; above 1,000, $400.

Fines up to $500 are imposed for selling to a minor without the consent of parents or guardian; doing business without a license in places where license is required; adulterating liquors with any deleterious substance; allowing minors to play games on the premises; furnishing liquor to an Indian, except the Pueblos; drinking, using, selling or disposing of liquor on election day; selling to an habitual drunkard, knowing him to be such, or to a person in the habit of getting intoxicated, after notice, or to an intoxicated person.

Druggists *may sell* on physician's prescription and liquor

be manufactured from fruits grown in the territory and sold i quantities of not less than one quart.

NEW YORK.

The following abstract of the Liquor Tax Law, as it is offi cially known, or the Raines Law, as it is popularly called, i taken from Mida's Compendium of Information for the Liquo Interests:

The word liquor shall mean all distilled or rectified spirit wines, malt and fermented liquors.

All liquor tax certificates will be issued by the state commis sioner practically without discrimination to anyone who pay the required fee, whether it be for a dive or a palace. Ever liquor tax certificate in New York City will cost $800 a year in Brooklyn, $650; in Buffalo and other leading cities, $500; i cities under 50,000 inhabitants, $350; in towns under 10,00 $300; in villages under 5,000, $200; in any other place, $100. Th tax certificates for the sale of bottled goods and liquors not t be drunk on the premises grade from $500 in New York Cit to $50 in the smallest boroughs. Every dining car, buffet ca and steamboat will be charged $200 for a liquor license.

Towns can vote on local option every two years. The consen of two-thirds of the owners of dwelling houses within 200 fee of a place must be secured before a certificate will be granted. A bond double the amount of the tax must be furnished, which i liable for every violation of the liquor tax law. The tax certificat must be posted in a window facing the street on the ground floor if the entrance is on that floor. No dry goods, grocery, provisio or drug store keeper can sell liquors to be drunk on the premise unless in some place entirely distinct from the regular place o business.

Only citizens of the United States and of New York can secur tax certificates. No liquor can be sold in any building belongin to the public. No bar can be within 200 feet of a school hous or church, except in hotels. No liquor can be sold anywhere o Sunday or between 1 and 5 a. m. on week days, except in hotel with meals or in rooms. No screens or shades can be draw to conceal the interior of the place during prohibited hours Any person selling liquor without a tax certificate shall be fine not less than twice the amount of the annual tax. This would make the fine $1,600 in New York City. Anyone violating the provisions of this act shall be fined not more than $500 or im-

prisoned for one year and forfeit the year's certificate. Two convictions will bar for five years the securing of a new certificate.

All clubs in which liquor is distributed must pay the same tax as hotels and saloons. They are not subject to visitation by excise inspectors, except on the direction of the excise commissioner. They may distribute liquors to their members at any time, provided they were incorporated prior to March 23, 1896, the date when the original tax law was signed. Clubs organized since that time will not be permitted to distribute liquor on Sundays, election days, or between the hours of 1 and 5 o'clock in the morning.

Hotels, within the meaning of the law, are such as have at least ten bedrooms for guests above the basement floor. These must be separated by partitions not less than three inches thick, which must extend from floor to ceiling. Independent access to every room must be provided from a hallway. Every room must have at least 80 square feet of floor space and 600 cubic feet of air space. A window must be provided for every room. The hotel dining room must contain at least 300 square feet of floor surface, and have accommodations for at least twenty diners. The bar may not be in the dining room. Guests of hotels are defined to be persons who hire rooms at regular rates not merely to be served with drinks, or such as resort to the hotel for meals at the regular hours when meals are served.

Beer bottlers have to pay a tax of $100 for every delivery wagon they employ. The pharmacists' tax has been reduced to $25 in the city and $5 in the country town. A dealer in liquors who knowingly employs in his business a man who has been convicted of a felony is guilty of misdemeanor. Liquors may not be sold to a minor to be used by another. Permits to sell liquor all night at balls and entertainments may be obtained of the mayors of cities of the first class for $5 a night. Any citizen may secure an injunction to restrain the illegal sale of liquor. Violators of the law in New York City are to be tried exclusively in the Court of Special Sessions. (No jury.)

NORTH CAROLINA.

A license tax of two per cent on the total amount of purchases is paid by a person who buys liquors for the purpose of selling them. Druggists pay $50 per annum for dealing in liquors, but can sell only on the prescription of a practicing physician; a violation of this provision is punishable as a mis

demeanor. A license tax is payable semi-annually in advance by any person selling liquors, or any social club or association handling liquors for the use of its members or guests, for selling in quantities of five gallons or less, $50 for each six months; for selling in quantities of five gallons or more, $100 every six months; for selling malt liquors only, $10 for six months. Wines of one's own manufacture or spirits may be sold in quantities not less than one quart at the place of manufacture or within 100 yards of it. Counties may levy an additional tax not greater than that imposed by the state. Incorporated cities and towns may lay an annual tax, not to exceed $25, for retailing liquors, or selling in quantities of one quart or less, except druggists.

It is a misdemeanor punishable by fine to adulterate liquors or knowingly sell adulterated liquors, or liquors containing properties or ingredients poisonous to the human system; to retail liquors otherwise than prescribed by law; to sell to an unmarried person under the age of 21, knowing him to be such; to sell liquor on Sunday; for a druggist to sell otherwise than on the prescription of a practicing physician.

Fines are imposed as follows: $10 to $50 for selling liquor within four miles of the state university, or to any student at such university without permission in writing from some member of its faculty; $100 to $1,000 for selling liquors within five miles of a polling place within twelve hours of a public election.

Wines made from fruit raised in the state and unfortified may be sold in bottles corked and sealed up, not to be drunk on the premises, in any quantity. This does not authorize sale of wine to minors. Where prohibition is asked for a greater distance than two miles the question is decided by an election in any city, county, town or township not oftener than once in two years.

NORTH DAKOTA.

The constitution prohibits the manufacture and importation of intoxicating liquors for sale or gift, and the keeping, selling or offering for sale, etc. City councils have power to forbid and punish the selling of liquor to a minor, servant, insane person, habitual drunkard or intoxicated person.

It is a misdemeanor to sell liquor within one mile of a religious meeting, except in duly licensed places; to bring liquor for sale

into a courthouse, jail or prison; to adulterate or dilute liquor with fraudulent intent or sell such liquor; to sell to an Indian; to sell on a steamboat at a wharf on Sunday.

Fines up to $1,000 are imposed for selling liquor on election days; violation of city ordinances concerning the liquor traffic; manufacturing, importing, selling or keeping for sale liquor for a beverage; selling liquor for medicinal, scientific, or mechanical purposes without druggist's license; physicians prescribing liquor except in case of actual need; obtaining liquor from druggist on affidavit and using or selling it as a beverage; druggist failing to observe the regulations imposed by law; keeping a clubhouse with liquor for members; druggist selling liquor to a person after notice from relatives or guardians not to do so; carrier knowingly delivering liquor to be used unlawfully.

Druggists must secure a license, the fee for which is $5. They can sell only upon physician's prescription or upon affidavit of purchaser, and must allow no drinking of liquor on the premises. The affidavits are required to be kept in a certain prescribed way and deposited in the county court each month.

Premises may be searched for liquor, and all liquor and vessels containing it seized. Places where liquor is sold unlawfully are common nuisances and may be closed up and perpetually enjoined from operation, and the liquor found in them seized and destroyed.

OHIO.

The Dow law imposes an annual tax of $350 on persons who traffic in intoxicating liquors for every place where such traffic is carried on, payable in semi-annual instalments. This does not apply to the sale at the factory in quantities of not less than a gallon. Brewers have been held liable to pay tax on every agency. Of the tax $50 goes to the state, the balance to the county and certain other funds. Sunday selling is prohibited except by druggists on prescription. Municipal corporations may regulate, restrain and prohibit the retail trade. Selling to a minor except on written order from parent, guardian or physician, is prohibited, also to an intoxicated person, or one in the habit of getting intoxicated, selling within certain distances of school houses, seminaries, colleges, at fairs, on election days and festivals, near soldiers' and sailors' homes and religious gatherings, or between 12 and 6 a. m.

Public schools are required to teach the nature of alcoholic beverages and narcotics and their effects on the human system, teachers being examined as to these subjects.

Special provisions apply to the big cities of Cincinnati, Columbus, etc. A local option provision enables districts to prohibit the liquor traffic entirely by election every two years, the payment of the tax not being equivalent to a license, as the state constitution forbids the passage of any license law. Civil liability for the injuries caused by intoxication is fixed after notice not to serve liquor. A person who takes charge of an intoxicated person is entitled to recover his expenses from the one who supplied the liquor. The employment on railroads of persons addicted to habits of intoxication is prohibited. Minors under 18 years of age are prohibited from entering any place where liquors are sold except in the discharge of lawful business or when accompanied by parent or guardian.

All domestic spirits are to be inspected under penalty of fine of $100 to $500. Each package must be branded with the name of the manufacturer and the words "containing no poisonous drug or other added poison." Adulteration of liquor is punished by fine of $100 to $500. Wine is defined as adulterated if it contains any alcohol in addition to that generated by the natural fermentation of the grape juice, or any sugar, water or other foreign substance. All wines containing less than 75 per cent of pure, undried grape juice are marked as "compounded" wine. Violations of these provisions are punishable by fine from $100 to $1,000.

OKLAHOMA.

The excise laws of this state do not extend to those tracts of land within the state to which the Indian title has not yet been extinguished, including allotments, all of which still remain subject to the United States laws applying to the Indian Territory (which see).

Municipal authorities have power to license, regulate, prohibit or suppress the liquor traffic, city, town or village authorities having jurisdiction within the corporate limits and two miles beyond, the county authorities in all other places. License fees are: $200 for retailing all liquors in rural districts; $100 to $500 in cities, towns and villages; wholesaling, $100, and for malt liquors exclusively, $25, the wholesale limit being four and one-half gallons.

Fines run up to $500 for the following offenses: Violating municipal ordinances relating to the liquor traffic; selling liquor within one mile of any religious gathering except at regular licensed places; selling on days of general election; selling within a courthouse except at a place designated by the county commissioners; adulterating liquors for sale, or selling such liquor; selling to any Indian; selling on Sunday; selling to minors without written order of parent, guardian or family physician, to apprentices or servants under age, to intoxicated persons or persons in the habit of getting intoxicated; for selling without a license or in violation of the terms of the license; keeping open between midnight and 5 a. m.; selling to any person after notice from a justice of a peace not to do so; permitting gambling; obstructing the view from the street by screens, etc.

Persons may sell wine in quantities not less than one gallon made from grapes grown by them on their land, without a license.

OREGON.

Licenses with fees of $400 for all liquors and $2000 for malt liquors only, are granted in the discretion of the county court, municipal authorities of incorporated cities and towns being authorized to impose special terms, and to license, tax, regulate and restrain the liquor traffic. Applicant must give a bond of $1,000. He must secure the consent of a majority of the legal voters in the precinct and a greater number than is signed to any remonstrance against the license. The petition, with the names of the signers, is published for four weeks. Wine growers may sell their product without a license in quantities not less than one quart.

Fines up to $500 are imposed for the following offenses: Violating ordinances regulating the liquor traffic; selling adulterated drinks; keeping a disorderly house; permitting unlawful gaming or riotous conduct; keeping open on Sunday; selling to minors, habitual drunkards, or intoxicated persons; selling without a license; selling within half a mile of the grounds of the Oregon State Agricultural Society, or any other agricultural society, without the written consent of the officers of such society; allowing minors to loiter around place where liquor is sold; selling within four miles of any place where the general government is constructing canals, locks, etc.; selling

to Indians and half-breeds living with Indians; selling within two miles of any religious assembly.

PENNSYLVANIA.

Authority to grant licenses is vested in the court of quarter sessions. Applications are filed three weeks before the beginning of a term and published three times in two newspapers. The application must state that the place is necessary for the accommodation of the public, that none of the applicants are pecuniarily interested in the sale of liquors at any other place in the county, that the applicant is the only person pecuniarily interested in the business, and if the applicant held a license during any part of the year and if it was revoked. Two reputable freeholders of the ward must be sureties for $2,000. The bondsmen must not be engaged in the manufacture of liquors and if on more than one bond must qualify in $4,000 over all incumbrances and other bonds signed. Twelve qualified electors of the ward must certify that they know the applicant, believe his statements to be true, and ask that the license be issued. The court may hear remonstrances against the application and must refuse to issue it if the place is not deemed necessary for the accommodation of the public and entertainment of the traveler or if the applicant is unfit. The court may revoke a license for any violation of the laws. The applicant must execute a bond for $2,000 with confession of judgment attached.

License fees are: Brewers who produced less than 1,000 barrels the preceding year, $250; 1,000 to 2,000 barrels, $300; 2,000 to 3,000 barrels, $400; 3,000 to 5,000 barrels, $500; 5,000 to 10,000, $750; 10,000 to 20,000 barrels, $1,000; every 10,000 barrels more, $250 additional up to 100,000, which takes a license fee of $3,000; 100,000 to 150,000 barrels, $4,000; 150,000 to 200,000 barrels, $4,500; 200,000 to 300,000 barrels, $5,000; more than 300,000 barrels, $6,000.

Distillers' licenses are similarly graduated. New breweries and distilleries pay $1,000 for the first year regardless of production. Brewers paying $1,000 license may sell to licensed liquor dealers malt beverages of their own manufacture in packages of not less than twelve pint bottles or casks of not less than one-eighth barrel, and deliver their product in the county in which they are licensed.

Retail dealers pay the following license fees: In cities of

the first and second class, $500 to $1,000; cities of the third class, $500; in other cities, $300; in boroughs, $150; in townships, $75. In cities of the first class, four-fifths go to the city and county, one-fifth to the state; in cities of the second and third classes, two-fifths to the city, two-fifths to the county, one-fifth to the state; in other cities and boroughs, three-fifths to the city or borough, one-fifth to the county, and one-fifth to the state; in townships, one-half to the township, one-quarter to the county, and one-fourth to the state. In addition, licensed dealers pay for the state in cities of the first and second class, $100; in other cities and boroughs, $50; in townships, $25.

Penalties for selling without a license are $500 to $5,000 and imprisonment for one year; for violation of the laws governing licensed places, $100 to $5,000 and imprisonment for 3 to 12 months; for keeping a disorderly house, revocation of license.

Druggists pay no license fee and may sell spirituous liquors only on the written prescription of a regular physician. Alcohol may be sold for scientific, mechanical or medicinal purposes.

RHODE ISLAND.

High license and local option prevails. A local option vote is taken upon the petition of 15 per cent of the votes at the preceding general election (in cities 10 per cent). If "no license" is voted, none can be issued. If licenses are allowed they are issued by town councils, and in cities by boards of commissioners appointed for that purpose by the mayor. Applications for license are published, and objections heard by the licensing authorities. Manufacturing license, which authorizes wholesale or retail dealing, fee $500 to $1,000; license to sell in quantities less than two gallons in the city of Providence, $400; other cities above 15,000 population, $350; towns of 6,000 to 15,000 inhabitants, $300; elsewhere, $200 to $300. Selling liquor on Sunday, to minors or notoriously intemperate persons, to women for drinking on the premises, or on a passbook or order is prohibited. Penalties for violation are $20 fine and imprisonment for ten days for the first offense and increasing for subsequent offenses. The license may be forfeited, and in that case a new one cannot be obtained for five years. Suit upon the bond is authorized. Gambling, keeping disorderly house or any viola-

tion of state laws involve forfeiture of license. Houses may searched and liquor unlawfully kept, confiscated. No license required for the manufacture and sale of cider, or of wine malt liquors for domestic use, alcohol for export, or wine quantities of one gallon or more from fruits grown in the st Pharmacists may sell for medicinal purposes without a licer Persons injured by an intoxicated person have a right of act against the latter and against anyone who furnished him w liquor in violation of law.

A fine of $100 to $1,000 is provided against any per keeping a place where liquor is illegally sold, or who lets a bui ing for such purpose.

Intoxicating liquor means all liquor "containing more th two per cent by weight of alcohol or containing less than t per cent if the same is intoxicating."

Limit of retail dealing is two gallons.

Fines are: $100 for selling liquor to women or a minor, be drunk on the premises; $20 for forcibly ejecting an into cated person to whom the dealer has sold liquor; $20 for fi offense, $50 for second, and $100 for each subsequent offe for violating any of the license provisions; $50 for selling Sunday or on election day; $20 for transporting liquor to sold unlawfully; $100 for first and $200 for subsequent offen for illegal manufacturing; $100 to $300 for selling impure adulterated liquors; $300 to $500 for selling liquors adulterat with any poisonous or deleterious ingredients injurious health; $200 for adulterating liquors.

SOUTH CAROLINA.

This state has the famous dispensary law, which makes t liquor traffic a state monopoly. The following description of t law is taken from the annual report of Excise Commission Lyman of the state of New York, January, 1898:

The state board of control, consisting of the governor, t comptroller and the attorney-general, appoint in each coun a board of three persons not "addicted to the use of intoxicati liquors," and these county boards appoint "dispensers of liquo There may be one dispenser for each county, ten for the city Charleston, and three for the city of Columbia. Others may appointed wherever the board thinks they are necessary.

The dispenser must present his application for a "permi

stating his name, place of residence, business, and in what business he has been engaged for the last two years; that he is a citizen of the United States and of the state of South Carolina; that he has never been adjudged guilty of violating the law relating to intoxicating liquors, and is not a licensed druggist, a keeper of a hotel, eating house, saloon, restaurant, or place of public amusement, and that he is not addicted to the use of intoxicating liquor as a beverage. This petition must be signed and sworn to by the applicant, and must also be signed by a majority of the freehold voters of the incorporated town or city in which the permit is to be used, each of whom must state that, before signing, he has read the petition and understands its contents and is well and personally acquainted with the applicant. The dispenser must execute a bond in $300, with sureties, and give an undertaking to comply with all the requirements of the act.

Before delivering intoxicating liquor to any person, a request must be presented to the dispenser, printed or written in ink, correctly dated, stating the age and residence of the signer, for whose use the liquor is required, the quantity and kind requested and his or her true name or residence, and, where numbered, by street and number, if in a city; and the request must be signed by the applicant in his own true name and signature, and attested by the county dispenser or his clerk, who receives and files the request in his own true name and signature, and in his own handwriting. It must be refused if the dispenser knows that the person applying is a minor; that he is intoxicated, or in the habit of using liquor to excess; or if the applicant is not so known to the dispenser, he shall require identification and the statement of a reliable person of good habits who is known to the dispenser, that the applicant is not a minor and is not in the habit of using intoxicating liquors to excess.

Blank forms of request for the purchase of liquors are furnished by the state board of control, and each dispenser must make full returns, monthly, to the county auditor, with his sworn statement that he has made full disclosure of all business done by him.

A state commissioner, who is an abstainer, is appointed by the governor, whose business it is to purchase pure liquor (giving the preference to manufacturers and brewers doing business in

the state), and sell it to the county dispensers at a price not ceeding 50 per cent above the net cost. This provision does apply to beer shipped in bottles, cases or barrels.

No liquor, except beer, is to be brought into the state, transported within it, otherwise than in a package bearing certificate with the signature and seal of the state comission under a penalty of $500.

Manufacturers doing business in the state are allowed to s to no one in the state except the commissioner, and he is sell only to county dispensers, in packages of not less than half pint, nor more than five gallons. The county dispensers not permitted to break the packages, nor to purchase of anyo but the state commissioner. Purchasers must not open package on the premises.

The dispenser must not charge more than 50 per cent abo cost, and in sales to druggists for compounding prescriptions more than 10 per cent.

The proceeds of sales by the state commissioner go to state; those of sales by the dispensers, after payment of penses, are divided equally between the county and the municip ity.

Anyone concerned in keeping a club room or other place wh intoxicating liquors are received or kept for barter or sa division or distribution among the members, is punishable by fine of $100 to $500, and imprisonment three to twelve mont A place where liquor is illegally sold may be declared a nuisan and by judicial proceedings abated, closed and perpetually joined. Heavy penalties are provided against all who violate disobey the law.

SOUTH DAKOTA.

A general license law, coupled with local option, prevails. the annual municipal election in townships, towns and cities up petition signed by twenty-five legal voters, thirty days befo election, the question: "Shall intoxicating liquors be sold at tail?" is submitted to the voters. Only if the election is in favor such traffic can licenses be issued.

Licenses are issued by the county treasurer upon payment $400 for selling intoxicating liquors at retail; $600 for selling m *liquors at* wholesale; $1,000 for selling spirituous liquors *wholesale*; $400 for manufacturing malt liquors; $1,000 for m

ufacturing spirituous liquors. Each place of sale must be licensed. The wholesale limit is five gallons. No license is imposed on the sale of wine or cider from fruits grown in the state, unless sold by the drink. The license is required to be posted in a conspicuous place. No license can be granted to any person who has ever served a term in any penitentiary or shall be convicted of keeping a disorderly house. In addition, cities and towns may impose licenses from $200 to $600.

Penalties are fines of $50 to $500, or imprisonment for not more than 30 days, or both, for doing business without a license; selling to a minor or intoxicated person, a person in the habit of getting intoxicated, or to any other person where forbidden in writing by husband, wife, parent, child, guardian or employer, supervisor of the township, or president or a trustee of the town, mayor of a city, or board of county commissioners; obstructing doors or windows; allowing games to be played; allowing minors to enter; keeping open on Sunday or election day, or between 11 p. m. and 5 a. m.; adulterating liquors with any deleterious substance. Violation of any of the provisions of the liquor law also works a forfeiture of the license.

A bond of $2,000 is given to obey the law and pay all damages that may be adjudged against the dealer. The bondsman must not be engaged in the liquor business and must be a freeholder and resident of the county, township or city.

The municipal authorities may refuse a license if the applicant is of immoral character or is deemed unfit for the business. The application is accompanied by a petition signed by twenty voters and published for two weeks. No place for the sale of liquor can be located in the same block with, or adjacent block to, any school or within 200 feet of any church. Druggists may sell without license for medicinal, scientific, mechanical or sacramental purposes.

TENNESSEE.

The right to sell liquor is declared by the code a taxable privilege and cannot be granted to persons who are incompetent to be witnesses in the courts of justice, or to any person who has been convicted of violating a former license by keeping a disorderly house or permitting gambling, or who has been twice convicted of an unlawful sale to minors. The applicant gives to the county clerk a sworn statement of the value of the liquor he in-

tends to offer for sale, and a bond of $500 to keep an orde house and comply with the law, and takes an oath not to pern gambling or any violation of law in the place licensed, nor mix or adulterate liquors.

The rates of taxation are as follows: Brewers $200, includi agents of foreign breweries; bottlers, except bottlers of mine waters and brewers who bottle their own beer, $75; distilleries whisky and brandy of the capacity of twenty barrels and over day, $250; 10 to 20 barrels, $150; 5 to 10 barrels, $70; und 5 barrels, $5; wholesale liquor dealers, $200; retail liquor deale in places of 5,000 inhabitants or over, $200; in smaller place $150. Retailers are persons selling in quantities of one gallon less. These taxes apply to druggists, except for the sale wine for sacramental purposes and alcohol for domestic purpos Persons or corporations selling on boats, railroad cars, etc., $3

Fines are up to $500, and in some cases imprisonment, for frau ulently adulterating liquors for sale; selling without license; se ing any liquor in any factory, mine, quarry, etc., owned by a fo eign corporation; selling within one mile of any place of pub worship; selling in places of amusement or within half a mile o fair; keeping open on Sunday or election days; selling to studer of any educational institution; selling to minors without consent parent or guardian; selling to an habitual drunkard after writt notice from the wife not to do so; selling within four miles any incorporated institution of learning, or school-house, exce in cities or at wholesale by regular licensees.

TEXAS.

License and local option is the law of the state. The comm sioners' court for each county may, and upon petition of 2 voters must, order an election on the question whether liqu shall be sold or not. Such elections cannot be held oftener th every two years. If prohibition fails to carry in a county t does not prevent a vote being taken in a precinct or distr within the county, but if prohibition is adopted for the county cannot be nullified by vote in a district or precinct within t county.

Where liquor selling is allowed the state collects a license t of $300 for retailing in quantities less than one quart, $200 quantities of 1 to 5 gallons, $300 in quantities of 5 gallons a ward, $50 for malt liquor only. Towns and villages may le

an additional tax of one-half the state tax. City councils have full power to license, tax, and regulate the traffic, including breweries and distilleries. The licensee must give a bond of $5,000 and pay a penalty of $500 for any violation of a condition of the bond.

Fines are provided up to $500 for violating any city ordinance relating to the liquor traffic; selling liquor without a license, keeping a disorderly house; selling to minors without written consent of parent or guardian, to students, habitual drunkards, or any other person after written notice from proper parties not to sell to him; allowing games prohibited by state law to be played on the premises; failing to keep license posted in a conspicuous place; keeping open within three miles of an election precinct on an election day; selling to an Indian of the wild and unfriendly tribes, or of the Choctaw or Chickasaw territory; selling liquor in prohibition districts; running a "blind tiger;" adulterating liquor with any substance injurious to health, or selling liquor so adulterated.

UTAH.

A license law prevails in this state. The licensing authorities are the city councils in cities, and county boards outside of the cities. City councils have exclusive power to license, tax, regulate and prohibit the liquor traffic, the state law being operative in that respect only outside of the cities. License fees in counties must be $600 to $1,200. The granting of licenses is discretionary with the authorities. Licensees give bond to obey the law and pay damages. Vine growers may make wine from their own fruits and sell in quantities not less than five gallons without a license. Municipal authorities may, by proclamation, forbid the sale of liquor on a legal holiday.

Fines up to $1,000 and in certain cases imprisonment up to six months are provided for the following offenses: Selling liquor to an Indian or half-breed, or any person living with an Indian woman; selling without a license; adulterating or diluting liquors with fraudulent intent; selling liquors to minors under 16 years of age; having females playing instruments, dancing, etc., in saloons; selling liquor within one mile of any religious meeting, except regular dealers; selling liquor in theaters, museums, circuses, etc.; keeping open on Sunday or on election days; selling liquors not inspected by state inspectors; selling

to an insane person or to a minor without written consent of parent or guardian, or to allow such persons to remain about the premises; selling to habitual drunkards; permitting gambling or disorderly conduct.

VERMONT.

Prohibition prevails. A commissioner is elected in each county every two years and appoints an agent in each town to sell liquors for medicinal, mechanical and chemical purposes. The liquor is bought by the municipal council (selectmen) and the proceeds paid into the town treasury. Heavy fines are provided if the selectmen make a contract with the agent that tends to increase his sales or if he is paid any other compensation than a fixed sum of money. The manufacture of spirituous or fermented liquors is prohibited, except wine for the Lord's Supper, cider and wine from grapes or fruits grown in the state without any admixture of alcohol, and fermented liquors for one's own use. The sale of liquor is prohibited except for the purposes stated. Fines for the unlawful sale of liquor are $5 to $100, and possibly imprisonment up to 30 days, for the first offense, and for the second and each subsequent offense, fines from $10 to $200 and compulsory imprisonment from one month to one year. Prosecuting officers are subject to fines of $300 to $500 for failure to enforce the law. The transportation of liquors intended to be sold unlawfully is forbidden. A common seller of liquors, not being a lawful agent, is fined $100 for the first offense, and $200 for subsequent offenses, and on the third or subsequent conviction shall be imprisoned four to twelve months. Informers get half the fine collected. Liquors intended for unlawful use may be confiscated. Soliciting orders for liquor is prohibited. Imported liquor must be marked with the name of the consignee. Parties who furnished liquor contributing to the intoxication of a person are liable in damages if the intoxicated person injures any one, and if the intoxicated person is imprisoned, must pay $2 a day to the wife or children under age. Owners of buildings having reason to know that liquor is sold there are liable for injuries caused by such intoxication. Places where liquor is unlawfully sold or kept are public nuisances.

Adulteration of liquor or sale of adulterated liquors is subject to fine of $300.

VIRGINIA.

The system is license with local option, administered by a state board of commissioners of excise who appoint three commissioners for each city. This board examines for itself the necessity, convenience and fitness of any proposed licensed place and the character of the applicant. Remonstrances against applications may be heard. If the application is granted the licensee must file a bond of $250 to $500. An appeal lies to the circuit court from the decision of the board. License fees are as follows: Wholesale (general), $350; wholesale (malt liquor only), $150; retail in towns of not more than 1,000 population, $75; retail for malt liquor only, $30; retail elsewhere, $125; bar-rooms in towns of less than 1,000, $75, and 15 per cent of the rental value of the room; bar-rooms elsewhere, $125, and the same 15 per cent; malt liquor saloons in towns under 1,000, $40; same elsewhere, $60; license for "ordinary" in towns under 2,000, $75; same elsewhere, $125, and 8 per cent of the rental value of the house and furniture up to $1,000; 5 per cent up to $2,000, and 3 per cent upward of $2,000; "sample liquor merchants" pay a license tax of $350. License for "ordinary" includes sale for consumption on the premises, not off. Separate licenses are required for wholesale and retail, or retail and bar-room business by the same person.

Sale on election day is prohibited under penalty of $1,000 fine and imprisonment up to 12 months.

Elections as to license or no license are held in counties on the petition of one-quarter of the voters. If no license is voted it includes the prohibition of wine or malt liquors by distillers and manufacturers.

A number of special acts prohibit the sale of liquor in different localities.

WASHINGTON.

A system of license with fees from $300 to $1,000 prevails, the governing bodies in incorporated cities, towns and villages having the exclusive control within the corporate limits, and the county commissioners outside. All liquors are required to be inspected by local liquor inspectors who receive a fee of 50 cents a barrel and 12½ cents per dozen bottles. If found adulterated, the liquor is analyzed, and if found impure, is destroyed. Licensing authorities may regulate and prohibit the traffic. The licensee

gives a bond of $1,000 and is civilly liable for selling to habitu drunkards. The owner of premises in which liquor is sold also liable for injury resulting from consequent intoxication, b has a right of exoneration against the vendor. A minor und 21, and over 18 years of age, who represents himself to be age in order to get liquor, may be fined $25 to $100, or imprison up to three months. Druggists may sell liquor without a licen upon the written prescription of a reputable physician, also alcoh for mechanical and scientific purposes upon written certificat and wine for sacramental purposes to a church officer upon wri ten certificate. Keeping a place for the sale of liquor contrary law or allowing it to be kept on one's premises is a public nu sance and subject to fine of $1,000.

Penalties are up to $1,000 for the following offenses: Allowi children under 18 years to enter a place where liquor is sol employing females in saloons, etc.; selling liquor on electi day or Sunday; selling without a license; selling to a minor wit out the written permission of parent or guardian; selling to I dians; violating municipal ordinances regulating the liquor traff

WEST VIRGINIA.

Licensing is left to the towns and other municipalities, und which arrangement the liquor traffic may be entirely prohibite State licenses are issued when authorized by the county cou but in an incorporated city, village or town, by the municip council, no licensed place being permitted within two miles of a city, town or village in which there is no license, without t consent of the council. If a hotel or tavern licensed to sell liqu shall fail to provide travelers or their servants with lodging a diet, the license may be revoked, and if the place is used simp for the purpose of selling liquor it shall be revoked.

License fee on hotels or taverns, 3 per cent per annum of t yearly value of the premises; retail license (up to five gallons $350; wholesale license, $350, in addition to all other tax License to furnish drinks at theater, $150; to sell at retail app and peach brandy distilled in the state from fruit grown in t state, not to be drunk on the premises, $100; retail license f domestic wine, ale, beer and similar drinks, $100.

Under the constitution forfeitures and fines go to the suppo of free schools.

Fine for failing to close places where liquors are sold on ele day, $50 to $100.

Brewery Licenses: 25,000 barrels a year or more, $550; 15,000 to 25,000 barrels, $350; 5 000 to 15,000 barrels, $200; 1,000 to 5,000 barrels, $125; 1,000 barrels or less, $50.

Temporary places for sale of liquor are prohibited within two miles of a camp meeting, or half a mile of any other place for religious worship, property of offenders to be seized and the liquor destroyed.

A fine of $500 is imposed for adulterating any article of drink. Druggists are fined $25 to $100 for selling without license, except for medicinal, mechanical or scientific purposes and upon the written prescription of a practicing physician in good standing and of temperate habits.

Fines for violating license provisions, $10 to $100; for selling to minors, insane persons, drunken persons or drunkards, allowing people to drink to intoxication on the premises, or on Sunday. Places where liquor is unlawfully sold to be considered public nuisances.

WISCONSIN.

License and local option prevail. A vote is taken on the question of license or no license in any city, town or village on the application of 10 per cent of the voters at the last election for governor. If prohibition is the result, the sale of liquor is punishable by fine or imprisonment, or both. If the vote is for licenses, they are issued by the board of supervisors in a town, trustees in a village and the mayor in a city. Special elections may be held in towns, villages and cities not oftener than once in three years to determine the amounts that shall be paid for licenses. The license is for the sale of intoxicating liquors to be drunk on the premises. The fees are in towns having in their boundaries no city or village with a population of 500 or more, not less than $100; elsewhere, not less than $200. These fees may be raised by vote to $250 or $400 in the first case and $350 or $500 in the second case. Pharmacists for a fee of $10 may sell for medicinal, mechanical and scientific purposes. If a permit is refused to a pharmacist he may sell only on prescription. Licensees must give bond in $500. City councils have power to license and regulate breweries, distilleries, etc.

Fines range up to $200 for the violation of ordinances or of the conditions of the license; for selling to minors, except upon the written order of parents or guardian; for keeping a disorderly house or permitting gambling; for selling to "a person intoxicated

or bordering upon intoxication," or to an habitual drunkard; f
selling without license; for pharmacist not keeping a record
sales of liquor or otherwise violating the conditions of his licens
for selling to any person given to the excessive drinking
liquors after having received notice from the wife or prop
county, city, village or town authorities not to sell liquor
him; for selling within one mile of insane asylums; for sellii
on Sunday, day of the annual town meeting or the annual f
elections; for selling to an Indian, except "civilized persons
Indian descent not members of any tribe"; for selling within tv
miles of any religious meeting, except at regularly establish
places.

Fraudulently adulterating liquors with any substance poisonou
deleterious or injurious to health, and knowingly manufacturir
or selling such liquor is punishable by fine up to $100.

WYOMING.

A county license is imposed on the liquor traffic. Retail dea
ers are those selling in quantities less than five gallons, an
their license fee is $500 a year if they are permitted to se
within five miles of any railroad or town, city or village, locate
on any railroad; in other cases the fee is $100. Persons sellir
liquor by the barrel, case or original package are wholesale dea
ers, and pay a county license of $175. To deal both at wholesa
and retail, both licenses must be obtained. In addition, cities an
incorporated towns have the right to license liquor dealers and
regulate, restrain or prohibit tippling houses, etc.

Fines up to $1,000 are imposed for the following offenses: Vi
lation of ordinances concerning the liquor traffic; selling an
pernicious or adulterated drink; adulterating liquors with fraudu
lent intent; selling liquor within one mile of any place
religious worship, except regular licensed dealers; selling betwee
the hours of 10 a. m. and 2 p. m. on Sunday, excepting hotels an
restaurants, and on election day; selling without a license; sel
ing to Indians; selling to minors or allowing them around th
place of business; selling to habitual drunkards; selling to an
person under 16 years of age.

BEER IN DIETETICS AND ECONOMICS

PURITY OF AMERICAN BEER.

WHAT ADULTERATION MEANS.

The purity of American beer has been of late much under discussion, and charges of adulteration have been bandied about with great freedom.

Adulteration is defined in the Century Dictionary as "the act of adulterating, or corrupting by the admixture of foreign and baser elements, especially for fraudulent purposes; debasement." To adulterate, according to the same authority, is "to make impure by the admixture of other or baser ingredients; corrupt; render counterfeit."

With regard to an article of food or drink, adulteration consists in either or both of two things. One is to manufacture and sell an article that is not what it purports to be, but may still be harmless. The other is to sell an article, so misrepresented, that is injurious to the public health. From these two points of view adulteration is treated by the legislative authorities.

WHAT BEER WAS AND IS.

Applying these points of view to beer, one is met at the threshold of the inquiry by the difficulty, that there exists no standard definition of beer. From ancient times down to the present the popular beverage that passed by the name of "beer" has been undergoing so many changes that it is impossible to fix any determinate meaning for that term, from usage alone, with sufficient accuracy to draw the line between genuine beer and an adulterated article. In olden times it seems the beer of the Teutonic tribes was a sweet fermented beverage in which honey was a prominent constituent, while the Slavs seem to have employed hops from the earliest time, for the purpose of imparting a bitter aromatic taste and, as they imagined, giving the stimulating effect. During the latter part of the middle ages, hops began to be used in Germany. Later they found their way into England, but as late as the time of Henry VIII their use was forbidden.

As to the cereal base of the beverage, barley and wheat seem to have been the earliest grains used. Barley having been the grain almost universally used by Europeans in antiquity as the staple article of food, was also largely used in producing beer. When the art of baking bread began to become popular, to which barley does not lend itself readily, that cereal was crowded out by wheat and rye as a food, but continued to be largely employed in brewing beer, for which purpose, however, wheat and probably other starchy cereals were also employed. In modern times the variety of cereals used in the preparation of beer has been much increased, and in the United States Indian corn and rice have been quite generally introduced. As the true function of starch in beer-making came to be better understood, the process of conversion into sugar was anticipated and performed before the material reached the mash tub.

The idea that the only pure beer is an all-malt beer is thus seen to be false, both actually and historically.

Beer is a beverage produced by alcoholic fermentation from a hopped infusion, either of malted cereals, preferably malted barley, exclusively, or with an addition of unmalted or prepared cereals.

REPORT OF THE UNITED STATES SENATE COMMITTEE ON MANUFACTURES.

The actual properties and mode of preparation of American beer were made the subject of an inquiry by a committee appointed by the United States Senate, 1899-1900, called the Committee on Manufactures. The report made by this committee, of which Senator Mason of Illinois was chairman, summed up its conclusions as to American beer, as follows:

"One of the most important subjects under consideration has been that of the great American Brewing Industry. The committee has, through its agents, visited ninety-two breweries in nineteen cities and purchased nearly 400 samples of their products in open market, and, under the evidence of the government analytical chemists who analyzed said samples, we find but two samples of American beer, ale and porter containing preservatives.

"While the imported beers do not rank as high as American beers, a much larger per cent of the imported beer samples analyzed were found to contain preservatives.

"Two very important questions present themselves to the committee in consideration of beers.

"First, as to whether there be a national standard fixed for beers, fixing the minimum amount of malt extract to be contained in the beer product.

"Second, whether we should adopt in this country the law which prevails in some parts of the German Empire, which provides that beer should be made of barley, malt and hops exclusively, or whether the American brewer should be permitted to use in conjunction with malt and hops other cereals, such as corn and rice.

"The present methods pursued by the American brewer are the same as contained in the English law governing their brewing industries. As a rule, the American brewers make many different kinds of beer in the same brewery. The American taste for beer varies from that of other countries and the tastes in localities also vary. Some require a light beer, as more pleasant to the eye as well as taste, while others desire a much darker grade of beer.

"When the American brewer uses other cereals besides barley, it is used in an unmalted state—that is, corn or rice—which gives a lighter color to the beer. It has been charged in a general, unsubstantiated way, by either a witness or through a communication, that these cereals did not produce as healthy a beer as an all-malt beer. But the overwhelming and almost uncontradicted evidence is that the use of corn or rice, for the purposes as stated, is not in the least deleterious to public health, and while the practical brewers, maltsters, chemists and analytical experts, as well as medical experts, approve the use of the unmalted cereals for the purposes as stated, whenever interrogated on that point, no witness has stated before this committee why the use of corn or rice unmalted, or other unmalted cereals, ought not to be used as it is all over the world.

"Mr. Gladstone, speaking in the English Parliament upon this question, said:

" 'The brewer will brew from what he pleases, and will have a perfect choice of his material and of his methods. I am of the opinion that it is of enormous advantage to the community to liberate an industry so large as this with regard to the choice of those materials.'

"The British parliamentary commission investigated this sub-

ject for four years, and the following is taken from their rep sustaining the bill which was passed upon the motion of Gladstone years before, which gave the free-malting privile to brewers:

"'It cannot be admitted that the liquor made from malt, ho yeast and water, only, has an exclusive right to the name of be or that the purchaser who demands beer demands an all-m liquor. Sugar was intermittently permitted to be used in b a century ago; for over fifty years its use has been continuou permitted by acts of Parliament, and eighteen years ago compl freedom in the use of all wholesome materials was deliberat granted to brewers by Parliament.'

"We also call attention to the following, taken from the Engl report:

"'The question as to the relative merits of different brew materials cannot be unconditionally settled with the data at pres available, but the balance of experience and authority inclines the view that while an all-malt brewing from a blend of m made from the best English and foreign barley is still the b for some descriptions of beer (pale bitter ale, for example), for other descriptions, which constitute by far the larger prop tion of the beer consumed, the medium or lower qualities British barley-malt (and our barley-malt is not any better, t is, the average barley-malt), are improved as brewing materi by the addition of a moderate proportion of good brewing sug and this is especially the case when the barley from which malt is made has been imperfectly ripened or harvested under favorable conditions.'

"The committee, then, is of the opinion that the present syst in America is fairest and more nearly just to the manufacturer a consumer to permit the brewer to be the judge himself of wh wholesome and healthy products he desires to be put into beer; and the bill, which we will finally present to Congress, w prevent the use of any unwholesome preservatives or deleteri substances.

"Much public concern has been excited because it has be charged that the American brewer uses a large amount of salicy or other acids to preserve the beers.

"The expert evidence before this committee is clear that a sm amount of preservative is not dangerous, while the evidence a

analysis of samples show that a very small amount of preservatives is used, and that by very few of the brewers, who use it in minutely small quantities to preserve bottled beer for export only. And the evidence is overwhelming that nearly every brewer and every bottler of beer in this country submits his bottled beer to the pasteurizing processes, which is simply submitting it to such an extreme heat in the bottle as to destroy germ life and prevent fermentation.

"The revenues derived from the great beer industry alone are $71,000,000, a double war tax. The value of money invested is $650,000,000, and the industry gives employment to 900,000 men.

"In the language of Mr. Gladstone, this committee feel that we should 'liberate as to choice of material and as to process of manufacturing an industry of so vast a scope as is this particular industry.'

"As to the other question, of fixing a standard of beer, ale and porter—that is, by fixing the minimum amount of alcohol, malt extract, etc.—every witness before this committee testified in favor of fixing said standard.

"Mr. Gallus Thomann, secretary of the United States Brewers' Association, favors such a law, as did every brewer and maltster who testified before this committee. And the committee is of the opinion that this may be done under the authority of the bureau that may be established in the Agricultural Department by Senate bill 2426.

"Whatever legislation may be passed should be national in its character. The brewing industry of this country has grown so extensively that the American brewers are selling their products not only in every state of the Union, but all over the world, and uniformity of standard, which is most desirable, can only be obtained by national legislation."

Analyses have also been made by state officials, all of which go to corroborate the conclusions of Senator Mason's committee, that American beer leaves nothing to be desired in point of purity, and will compare favorably with that produced in any other country.

A bill has been introduced in the United States Senate to create a chemical bureau in connection with the Department of Agriculture, which shall establish standards for articles of food and drink.

REPORT OF BRITISH BEER MATERIALS COMMITTEE.

The most exhaustive inquiry into brewing materials was m by a British parliamentary committee, known as the Beer terials Committee, which submitted its report in March, 1 As this contains much that also applies to conditions in United States, some of the important passages are here insert

In the introductory part this passage occurs:

"Broadly speaking, the main object of the transformati which the barley-grain—and the extract derived therefrom— dergo in the malt-house, the mash-tun, and the fermenting ve is first to convert the starch of the grain into fermentable su and next to convert the sugar in part into alcohol. At the s time certain by-products of the barley-grain, which do not dergo the same transformations, are carried along into the b Apart from such by-products the character of the finished ar is not altered by the use of some other starchy grain alongsid malted barley, or by the addition to the wort of sugar more or similar to the saccharine matter yielded by malt."

The malt adjuncts in use in breweries are classified as follo

"Details as to the various ingredients at present used in manufacture of beer will be found in the appendices. Those w are used as substitutes for, or adjuncts to, barley-malt ma roughly classified as·

"1. Corn and kindred materials, e. g., unmalted barley, rice maize rolled, cooked, or otherwise adapted for brewing by rious mechanical and chemical processes.

"2. Sugar and kindred materials."

"Of these the most important are:

"(a) Invert sugar, i. e., cane sugar treated by a process w renders it more easily fermentable.

"(b) Glucose, i. e., sugar prepared from starch by boiling acid. The starches chiefly used for this purpose are those der from sago and maize."

The general conclusions of the committee are laid dowr these words:

"Passing from these preliminary observations to the quest expressly put before us, we have to report that, so far as have been able to ascertain, no materials used in the manufac of beer are deleterious, at all events in the quantities in w they are actually employed. We believe that the exceptions to

rule, if any, are so infrequent and unimportant that legislation is not required to deal with them. We refer, of course, to materials of normal quality—any materials (not least barley-malt) may be unwholesome if they are bad in quality."

The objections that have been urged against malt adjuncts are stated in this form:

"1. That these adjuncts, or some of them, are, or may be, positively injurious to health.

"2. That, even if they are not positively injurious, the beer made with any proportion of them is less nutritious and wholesome than all malt beer.

"3. That, apart from the question of wholesomeness, the consumer is entitled to know what he is getting; that the product of malt and substitutes is not the same in "nature, substance and quality" as the product of malt only; that beer means or ought to mean a liquor prepared from malt and hops only; and that, therefore, on the principles laid down by the Sale of Food and Drugs Act, the consumer is prejudiced if an adjunct beer is sold to him as beer without a declaration of the use of the adjuncts."

On the first point the committee begins by saying:

"In respect of injury to health no serious charge has been made against raw grain, or prepared grains other than barley, or brewing sugar made from cane sugar. As to glucose, however, there has been some conflict of evidence. The question is not, however, of great practical importance with regard to beer, for it appears that potato glucose is not now used in brewing in this country; and we are informed that, while it is more expensive than maize glucose, it has disadvantages (other than its alleged unwholesomeness) from a brewer's point of view.

"With regard to glucose made from sago, maize, etc., it is generally admitted that there has been great improvement in the process of manufacture in recent years; and we believe that all impurities that might be considered injurious to health are eliminated."

The dietetic value of malt and its adjuncts is discussed in this way:

"It is generally admitted that, in the present position of scientific knowledge, chemical analysis, by itself, is an imperfect test of the *food value of any* article of diet. We are thus thrown back

on the aid of experience and common sense, but they do not yield any result possessing certainty and accuracy. But we may observe:

"(a) The amount of 'extract' (consisting of nitrogenous and non-nitrogenous organic substance, and ash) found by analysis in beer, and generally assumed to represent approximately the 'nutritive matter,' depends as much on the methods of malting, mashing, and fermenting as on the materials used, within the limits practically prevalent with regard to the proportions of the different materials.

"(b) The amount of organic extract in beer is, as a rule, small, and it is doubtful whether the dietetic value of beer (any more than the commercial value) varies at all directly with the amount of such extract which it contains. It is quite possible that a beer with a low proportion of organic extract may be more valuable as an article of diet, as well as more acceptable as a beverage, than a beer containing more extract, but inferior in flavor, brightness, soundness and digestive properties.

(c) Here follows the paragraph quoted on page 1106, beginning 'The question as to the relative merits. . . .'"

As to adulterations the committee says:

"The analogy which it as been attempted to draw between the case of beer and that of articles which are more nearly natural products, such as butter and coffee, is not, in our opinion, valid. Beer is in any case the result of a chemical process, whereas, when other fat is added to butter, or chicory to coffee, these ingredients remain as such in the mixture.

"Further, one malt wort is not necessarily identical with another malt wort, and the question as to the nature, substance, and quality of an article is obviously in part a question of degree. We are, however, satisfied that, so far as our present knowledge goes, a beer brewed with the usual moderate proportion of sugar does not, as a general rule, differ from an all-malt beer more widely than one all-malt beer differs from another."

The definition of beer which excludes malt adjuncts is laid aside by the committee once and for all in the following:

"It cannot be admitted that the liquor made from malt, hops, yeast and water only has an exclusive right to the name 'beer;' *or that* a purchaser who demands beer demands an all-malt *liquor*. Sugar was intermittently permitted to be used in beer a century ago; for over fifty years its use has been continuously

permitted by Act of Parliament; and eighteen years ago complete freedom in the use of all wholesome materials was deliberately granted to brewers by Parliament. Under these circumstances it must be presumed to be public knowledge that beer is not always made from malt and hops exclusively; and consequently we are of opinion that a person who demands beer and is supplied with a beer brewed with a proportion of malt substitutes is not thereby prejudiced.

"The question whether the law should be changed is, of course, a different one. If the liquor produced from malt only were clearly distinguishable from, and definitely superior to, the liquor brewed with a moderate proportion of malt adjuncts, it would be within the competence of Parliament, and might be in the public interest, to assign separate distinctive names to these liquors. But in our opinion this is not at present the case."

With regard to fanatical proposals for legislation, there occurs a passage which ought to be borne in mind by American legislators:

"We are satisfied that in the present state of scientific knowledge it is not possible to determine by chemical analysis with sufficient certainty to obtain a conviction whether malt adjuncts have or have not been used, except perhaps in cases where excessive proportions of such adjuncts have been employed.

"Consequently, a law making declaration of materials compulsory could not be enforced if we were to rely upon analysis for detection of violation of it; and we think that to create an offence, of which proof could not be established, would be undesirable."

INTEMPERANCE AS AFFECTED BY GENERAL NATURAL LAWS.

This subject is treated interestingly in the third annual report of the State Board of Health of Massachusetts by Dr. Henry I. Bowditch, and his letter was republished by the United States Brewers' Association under the title "Intemperance in the Light of Cosmic Laws." The board collected facts and opinions from a large number of correspondents and discussed the information thus brought together, summarizing the conclusions as follows:

First—Stimulants are used everywhere and, at times, abused by savage and by civilized man. Consequently, intoxication occurs all *over the globe.*

Second—This love of stimulants is one of the strongest of l man instincts. It cannot be annihilated, but may be regula by reason, by conscience, by education or by law when it croaches on the rights of others.

Third—Climatic law governs it, the tendency to indulge intoxication being not only greater as we go from the heat of equator toward the north, but the character of that intoxicati becomes more violent.

Fourth—Owing to this cosmic law, intemperance is very r near the equator. It is there a social crime and a disgrace of t deepest dye. Licentiousness and gambling are small offences co pared with it. To call a man a drunkard is the highest of sults. On the contrary, at the north of 50° it is very frequent, less of a disgrace, is by no means a social crime.

Fifth—Intemperance causes little or no crime toward t equator. It is the almost constant cause of crime either direc or indirectly at the north above 50°.

Sixth—Intemperance is modified by race, as shown in the d ferent tendencies to intoxication of different peoples.

Seventh—Races are modified physically and morally by the ki of liquor they use, as proved by examination of the returns fr Austria and Switzerland.

Eighth—Beer, native light grape wines and ardent spirits shou not be classed together, for they produce very different effe upon the individual and upon the race.

Ninth—Light German beer and ale can be used even fre without any very apparent injury to the individual, or with causing intoxication. They contain very small percentages alcohol (4 or 4.5 to 6.5 per cent). Light grape wines, unf tified by an extra amount of alcohol, can be drunk less free but without apparent injury to the race, and with exhilarati rather than drunkenness. Some writers think they do no har but a real good, if used moderately. They never produce t violent, crazy drunkenness so noticeable from the ardent spir of the north.

Ardent spirits, on the contrary, unless used very moderate and with great temperance, and with the determination to on them as soon as the occasion has passed for their use, are alm always injurious, if continued even moderately for any leng of time, for they gradually encroach on the vital powers.

used immoderately, they cause a beastly narcotism which makes the victim regardless of all the amenities and even the decencies of life, or perhaps they render him furiously crazy, so that he may murder his best friend. While those who live in the tropics merely sip slowly ardent spirits from the tiniest of glasses, with the slightest appreciable effect, the denizen of the frozen north swallows half tumblerfuls of the same to the speedy production of intoxication.

Tenth—Races may be educated to evil by bad laws, or by the introduction of bad habits. England's taste for strong drinks has been fostered by legislation and by wars of nearly two centuries since. France and parts of Switzerland are beginning to suffer from the introduction of absinthe and of schnapps. Especially is this noticeable since the late Franco-Prussian war. By classifying all liquors as equally injurious, and by endeavoring to further that idea in the community, are we not doing a real injury to the country by preventing a freer use of a mild lager beer or of native grape wine instead of the ardent spirits to which our people are now so addicted?

Eleventh—A race, when it emigrates, carries its habits with it, and for a time, at least, those habits may override all climatic law.

Twelfth—England has thus overshadowed our whole country with its love of strong drinks and with its habits of intoxication, as it has more recently covered Ceylon, parts of the East and Australia.

Thirteenth—This influence on our own country is greater now than it would have been if our forefathers, the early settlers, had cultivated the vine, which would have been practicable, as seen by the recent examples of Ohio and California, and from the fact that the whole of the United States lies in the region of the earth's surface suited to the grape culture.

Fourteenth—If these early settlers had done this, our nation would probably have been more temperate, and a vast industry like that of France, of Spain and of Italy and Germany, in light native wines, would long ago have sprung up.

Fifteenth—The example set by California and Ohio should be followed by the whole country where the vine can be grown. As a temperance measure it behooves every good citizen to promote that most desirable object. We should also allow the light,

unfortified wines of Europe to be introduced free of duty inst of the large one now imposed. Instead of refusing the Gern lager beer, we should seek to have it introduced into the pres "grogshops," and thus substitute a comparatively innoxious a cle for those potent liquors which now bring disaster and de into so many families.

Sixteenth—"Holly Tree" branches for the sale of good fo tea and coffee, cheaply to the people, should by the benevol co-operation of the community be made to take the places of numerous grogshops now open for the sale of ardent spirits.

Seventeenth—The moral sense of the community should be aroused to the enormity of the evils flowing from keeping an op bar for the sale of ardent sprits, while those for the sale of li wines and of lager beer should not be opposed, except for sale to habitual drunkards after due notice from friends. Sell violating such law might be compelled for a time to support family of their victim.

Eighteenth—The horrid nature of drunkenness should be i pressed by every means in our power upon the moral sense the people. The habitual drunkard should be punished, or if be a dipsomaniac, he should be placed in an inebriate asylum medical and moral treatment until he has gained sufficient se respect to enable him to overcome his love of drink. Th asylums should be established by the state.

EFFECTS OF BEER ON THOSE WHO DRINK IT.

A great deal has been, and continues to be, said by to abstinence agitators concerning the effect of beer on those w drink it, and as a rule their claims that such effect is injurious based on nothing but arbitrary assumptions and basel surmises.

In order to meet these misrepresentations the United Sta Brewers' Association some time ago undertook extensive e aminations among persons given to the use of beer, the results which were tabulated and analyzed by secretary Thomann, a published in pamphlet form. The data below are taken from tl pamphlet.

DEATH RATE AMONG BREWERY WORKMEN.

In a certain district of New York and Brooklyn, Dr. Gui Katzenmayer, Dr. H. F. Kudlich and Dr. Hugo Koethe e amined and practically had a monopoly of practice among g

brewery workmen. During five years thirty-six deaths occurred among these men from the following causes:

Deaths caused by accidents	5
Deaths caused by apoplexy and cerebral congestion	6
Deaths caused by tuberculosis of lungs	5
Deaths caused by typhoid fever	4
Deaths caused by pneumonia	4
Deaths caused by diseases of the heart	4
Deaths caused by diseases of the liver	4
Deaths caused by diseases of the kidneys	1
Deaths caused by insolation	1
Deaths caused by alcoholism	1
Deaths caused by chronic enteritis	1
Total	36

The only case of alcoholism on record invited a special inquiry into the drinking habits of the person in question, and it was found that in the last three or four years of his life the deceased had been addicted to the excessive use of ardent spirits. This case of alcoholism—a rare one among brewery workmen of any country—stood isolated not only on the list of deaths, but also on the sick lists from the districts investigated.

Of diseases of the heart, liver and kidneys, the recapitulation shows nine in all; that is to say, nine deaths occurred from diseases of that class, within five years, in a body of nine hundred and sixty brewery workmen. From disease of the kidneys but one man died within five years. If, in conjunction with this showing, it is stated that the average daily consumption of malt liquors by brewery workmen is twenty-five common glasses, or about ten pints, per capita, no more need be said, it is hoped, to disprove the assertion that the constant use of beer disorders, with fatal effect, the functions of the heart, kidneys and liver.

DEATH RATE AMONG OTHER CLASSES.

Before comparing the death rate among brewery workmen with the pertinent mortuary statistics contained in the United States census for 1880, it is necessary to state that such a comparison must inevitably be very favorable to anyone who intends to assail this position, because the benefit of doubt and of the inevitable inaccuracies of so gigantic a work as the census will be on his side. To begin with, he will have an advantage in that

the mortality report of the census does not, according to the ad mission of its compiler, include all the deaths that occurred withi the year covered by it, while the mortuary report submitte here, by a physician of the Benevolent Bureau, is absolutely ac curate. Here, then, the rate of death is given correctly, while i the census it is reported as being lower than it actually was. I addition to this, the fact should be considered that the statistic information given in the census report on mortality relates to th entire population, including the rich, the wealthy, and the wel to-do, to whom, so far as the death rate is concerned, the sma pauper element of our country forms no offset; while the statis tical showing herein contained relates to one single specified clas of craftsmen. This is a difference which, the impartial critic mu admit, is not in favor of the proposition sought to be proved i the case of the proposed comparison. Now let us compare figure

The number of deaths in our body of 960 brewery workme was 36, within five years; hence the average number of death within one year was 7.2. This places the rate of death pe thousand at 7.5. The ages of these brewery workmen range, i varying proportions, from 19 to 59 years. The only rates c death, contained in Vol. XI of the census, that can fairly b brought into a comparison with the foregoing showing, will b found in Table 6, page 25, which shows for the United State and for thirty-one registration cities "the proportion of deaths, i the different groups of ages, per 1,000 living." Of this tab only that portion can properly be reproduced here for compar son, which covers the "groups of ages" represented in our show ing, and, of course, only the figures relating to the urban popul tion will answer the present purpose. They are given as follows

Ages.	Proportion of deaths to 1,000 living.	Ages.	Proportion of deaths to 1,000 living
20-25	8.5	35-40	14.0
25-30	10.3	45-50	17.6
30-35	11.3	50-55	19.2

It might be said that these figures, so far as ages are cor cerned, do not correspond exactly with the figures of the Brew er's Benevolent Bureau, because they begin at 20 instead of 1 and end at 55 instead of 59. The disparity, which is unavoidab on account of the mode of grouping ages adopted by the censu -ials operates against the objects of this argument; seein

that the rate of death per 1,000 between 15 and 20 is only 5.5; while between 55 and 60 it is 28.3. The aggregate of living population in the above six groups of ages was 3,333,898; the total number of deaths 41,681; hence the rate of death per 1,000, within the stated age limits, was 12.5.

DEATH RATE IN THE UNITED STATES ARMY.

The death rate in the regular army of the United States during the fiscal year 1885—a year of peace, in which, as the Surgeon General's report states, no casualties from actual warfare were returned—was 10.9 per 1,000 of mean strength. Medical examinations at recruiting stations for the regular military service are conducted with a special view to securing men of good physique, of great strength and perfect health. Besides, as compared with the life a brewery workman, with its hard and steady work and manifold cares, the soldier's life in peace is an easy one. Excepting such accidents as are inseparable from the constant handling of fire-arms, the soldier, in times of peace, is exposed to fewer chances of disease and death than the average workman. Well-fed, comfortably quartered and clothed, he lives without cares or troubles, in a constant routine of healthful exercise. Yet, even as compared with the soldier in peace-time, we find that the brewery workmen have a great advantage in point of low rate of mortality. It is true, the deaths from accidents were uncommonly numerous in the army, their proportion to the deaths from all other causes being given at 31 per cent; that is more than again as large as the ratio of deaths from accidents among brewery workmen. But even so, the difference in favor of the latter is remarkable. The number of deaths in the army was 263 from all causes; the number of deaths from accidents was 83, in a body of soldiers of an average strength of 24,035. Deducting that number of deaths from accidents, which is in excess of the proportion returned for brewery workmen, we still have 46 more deaths, in a total of 263, than would have occurred at the rate of death among brewery workmen.

Compiling the monthly reports and sick lists rendered by Dr. Katzenmayer during five years, and classifying the causes of sickness in the usual general way, the relative proportion of the various diseases treated by said physician, during the period covered by his reports, is found to be as follows:

42.9 per cent of surgical cases caused by accidents of all kin fractures, dislocations, contusions, wounds, etc.

27.5 per cent of disturbances of the alimentary canal, acu catarrh of the stomach, intestinal catarrh, diarrhœa, dyse tery, etc.

12.5 per cent of rheumatic diseases.

9.4 per cent of diseases of the air passages; tonsilitis, dip theria, bronchitis, pneumonia, pleurisy, etc.

3.6 per cent of fevers; typhoid, intermittent, etc.

2.1 per cent of acute congestions of liver and kidneys.

1.0 per cent of diseases of the skin.

0.6 per cent of cerebral and spinal diseases.

0.4 per cent of diseases of the heart.

It will readily be admitted by everybody that among the enti population of the United States not another body of men equal number could be found, who, from their mode of life a drinking habits, would be better suited for such a purpose th brewery workmen. For, as a class, they drink beer and ale mo constantly and more copiously than the average beer-drinke For the information of those who are not acquainted with t usages prevailing in breweries, it must be stated that brewe workmen have at all times access to what in the jargon of t trade is styled the "Sternewirth," i. e., a room, set apart with every brew-house, where beer is constantly "on tap," to be used every one at pleasure and without cost. Every one drinks much beer as he thirsts for, without asking or being asked a questions as to his right to do so.

GENERAL HEALTH OF BREWERY WORKMEN.

One thousand men were examined as to their general state health, condition of liver, kidneys and heart. The men we weighed, their strength tested, and the length of time employe in breweries and average daily quantity of beer consumed a certained.

These examinations showed, that there are, in all, twenty-fi men out of one thousand, whose general state of health, or co dition of liver, or condition of heart, or condition of kidneys, not perfect; and that the remaining nine hundred and sevent five men enjoy exceptionally good health, and are of splend *physique.* The average daily consumption of malt liquors 25.73 glasses, about 10 pints, per capita.

Of the twenty-five men recorded as unsound, a very large proportion would not have been so classified if the examinations had been confined to the condition of the heart, the liver and the kidneys. But it was thought necessary to point out all those whose health was impaired from any cause whatever; no matter, whether the latter can be traced to the use of beer or not. Hence, when the "general state of health" was found, in any case, to be precarious, the physician had to make a corresponding entry in his list and explain the same under the head of special remarks by stating the cause or nature of the infirmity. This accounts for the fact that such diseases as icterus, bronchitis, rheumatism, tuberculosis of lungs, etc., are specified as causes impairing the "general state of health." Dividing the twenty-five unsound men according to the nature of diseases which impaired their health, we obtain the following:

Diseases of the liver	7
Diseases of the heart	1
Diseases of the kidneys	5
Emphysema	1
Rheumatism	6
Icterus	2
Bronchitis	2
Tuberculosis of lungs	1

The causes of the three first-named diseases are known to be so manifold, that it would be more than venturesome to assume, in the off-hand way of our opponents, that beer is at the bottom of them all. Yet no attempt will be made to weaken the showing as it stands, save in the case of Ch. W. (230), whose ailment, abscess of liver, was produced, to the positive knowledge of the physicians who performed an operation on the patient, by external injuries.

Rheumatism and diseases of the air passages are generally regarded by brewers as their trade diseases, produced either by constant exposure to the inclemency of the weather, as in the case of drivers; or by exposure to the sudden and extreme changes of temperature incident to the work in cellars, ice-houses and cooling-rooms; or by exposure to the constant moisture in wash-houses.

STRENGTH OF BREWERY WORKMEN.

As a rule, the men examined displayed unusual musc strength. The average weight lifted was 480 pounds; the lo weight indicated on the dynamometer, used by Dr. Katzenma being 390 pounds. Grouping the men according to the lengt time they are employed in breweries, we find the largest n ber in the group from five to ten years, there being about 30 it. From ten to fifteen years the number is 187, and from fif to twenty 122. Those who are engaged in brewing from month to two years are a little more numerous than those were thus engaged for over twenty, and less than twenty- years. The number of men at work over twenty-five years is In the first and last groups no unsound men were found; in other groups the numbers are as follows:

	Number of men.	Average daily quantit beer consumed per ca
From 2 to 5 years.....	2	23.02 glasses.
From 5 to 10 years.....	4	24.63 glasses.
From 10 to 15 years.....	6	20.00 glasses.
From 15 to 20 years.....	5	20.00 glasses
From 20 to 25 years.....	8	20.22 glasses.

PHYSIQUE OF BREWERY WORKMEN.

Comparing height of body and breadth of chest with the wei it will be found that, as a rule, brewery workmen are remarkable for obesity; on the contrary, the rare occurrence weight that does not correspond with the size of the men striking. It is reasonable to assume that the mode of life brewery workmen accounts for this favorable showing, and t the same quantities of beer, if consumed by men of sedent habits—shoemakers, for example—would produce different sults. The error made by nearly all writers on this subject ari from a misconception as to the difference between a const and an excessive use of malt liquors. The nature of the work which men are engaged and the general manner of living det mine the quantities of malt liquors men can consume with injury to their healths. It is a fact well known to every one w has devoted any attention to this matter, that the daily consun tion of beer among Germans, the majority of whom are habit *but not* excessive beer-drinkers, varies from five to twenty glass according to the nature of the occupation of the drinker.

CONCLUSIONS.

The conclusions to be drawn from the investigations are:

I. Brewers drink more beer, and drink it more constantly, than any other class of people.

II. The rate of death among brewers is lower, by 40 per cent, than the average death rate among the urban population of the groups of ages corresponding with those to which brewery workmen belong.

III. The health of brewers is unusually good; diseases of the kidneys and liver occur rarely among them.

The conclusion to be drawn from II and III is:

IV. That on an average brewers live longer and preserve their physical energies better than the average workman of the United States.

THE TEMPERANCE PROBLEM.

Alcoholism is a disease almost wholly peculiar to modern times. While it is true that processes of distilling spirits, more or less crude, were known to many different nations and tribes in all stages of savagery, barbarism or civilization, the use of distilled liquors was introduced into Europe among those nations with which we are concerned because we are descended from them, somewhere in the fourteenth century. It seems to have come from Spain where the Arabs had ruled for so many centuries, and the word "Alcohol" still shows its Arabian origin plainly. France seems to have been the first country to make distilled liquors for drinking. But it was the northern tribes that took to distilled liquors most kindly. They never made much headway in the southern countries against the wines which were indigenous. Fermented beverages, on the other hand, have always been known and used extensively. It would be difficult to find a tribe or nation that did not have its fermented drink. But until distilled liquors were introduced, alcoholism as a disease, sometimes fatal, was unknown. But the problem of alcoholism and of the drunkard is only a minor offshoot of the temperance question. There is only one drunkard in every 10,000 of population. The greater question is the prevention of the excessive use of alcoholic stimulants, which may occur and does occur without leading to drunkenness, and yet does much harm.

by a systematic diminution and the ultimate abolition of taxes upon wholesome beverages."

The commissioners sum up their observations in the assertion that the only practicable method of diminishing the evils of inebriety by governmental measures should aim at:

1. The suppression of technically imperfect distillation;
2. A system of taxation and administration by which the manufacture of, and traffic in, distilled spirits can be controlled and, if need be, restricted, and by which the collection of high duties on spirits is rendered feasible;
3. The reduction or abolition of taxes on wholesome beverages.

SIMILAR RESULTS IN THE UNITED STATES.

Observations in the United States fully bear out the conclusions so lucidly stated by the Swiss commission. Notwithstanding all attempts to break up the habits of excessive drinking prevailing in this country under the free whisky regime prior to the war of the rebellion, it was only when at the breaking out of the war of the rebellion the federal government was once more compelled to resort to the highest practicable tax upon whisky—the excise on beer and wine being comparatively low, thereby reviving the principles of Hamilton, Jefferson, Madison, Dr. Rush, Tench Coxe and other leaders in politics or temperance—that there was inaugurated that radical change in drinking habits to which the American people of to-day owe their position in the front rank of sober nations. Within this short space of time, viz., since July 1, 1862, the consumption of whisky, through the operation of the internal revenue tax law, has fallen from eleven to somewhat less than four quarts per capita, while in the same period the production of beer has risen from less than a million to more than thirty millions of barrels, and large quantities of domestic wines are consumed besides.

The statesmanship of the founders of the American republic appears in a new light when we remember the statement of Thomas Jefferson that "wine is the only antidote for whisky," or the conscious purpose of Hamilton to foster the brewing industry and reduce the production of spirits, to which end the first Congress and almost every session of the earlier Congresses was practically a unit as far as the moral ends to be achieved thereby

2. That under the operation of high license laws, the consumption of ardent spirits increases.

3. That the highest degree of drunkenness is found where ardent spirits are used most generally, while comparative sobriety prevails where fermented liquors are the common drink.

The conclusions for the United States must coincide with those for Switzerland, viz., that the restrictive effect of the laws should be confined to ardent spirits so as to impart to the traffic in fermented beverages greater power of expansion, and to enable the people to gratify a craving for stimulants, ineradicable in its present state of culture, by using the mild and wholesome beverages which are so rarely productive of inebriety in its pernicious and dangerous forms.

The system of indiscriminate high license produces results diametrically opposed to those which are desired.

REVENUE DERIVED FROM THE LIQUOR TRAFFIC.

The twelfth annual report of the United States Commissioner of Labor contained a statistical investigation of the liquor traffic from which some of the most interesting data are here reproduced.

The investigation covered the year 1896. It may be added that although the amounts found to be paid by the liquor traffic to the various governments in the country are almost incredibly large for that year, they have been enormously increased since that time. When it is considered that the internal revenue tax on beer was doubled for three years and is now (beginning July 1, 1901) about two-thirds higher than in 1896, that special taxes are levied on tonics, that beer is being taxed in some states and license fees are everywhere rising, while brewers and liquor dealers share in the various stamp taxes generally imposed on business transactions since the Spanish war, it is safe to say that an addition of 25 per cent to the rate of contributions from the liquor traffic to the national, state and municipal governments on the basis of the figures given by the Commissioner of Labor would not be excessive. To this should be added the increase coming from the natural growth of the liquor business. It is likely that for the year 1900 the total would not be far from $240,000,000. (See tables on pages 1126, 1127, 1128.)

SUMMARY OF CAPITAL INVESTED, TAXES AND RENT PAID, AND PERSONS ENGAGED IN THE LIQUOR TRAFFIC, BY STATES, FOR THE YEAR ENDING JUNE 30, 1896.

In compiling this table, representative internal revenue districts were canvassed. The facts given in this table relate only to the establishments within such districts from which reports were secured. The state totals show the facts, not for complete states, but for the parts canvassed only.

States.	Yearly Taxes.			Rent Paid During the Year.	Proprietors and Firm Members.			Average Employees During the Year. Number Actually Employed.			Average Employees During the Year. Number Required if Entire Time was Devoted to Liquor Traffic.		
	Real Estate.	Personal Property	Total.		Males.	Fem.	Total.	Males.	Fem.	Total.	Males.	Fem.	Total.
California	$ 116,336	$ 27,314	$ 143,650	$1,346,409	2,353	45	2,398	4,313	137	4,450	3,012	90	3,102
Connecticut	100,941	17,734	118,675	608,019	2,676	113	2,789	3,145	265	3,410	2,160	84	2,244
Delaware	6,249	....	6,249	30,243	317	21	338	353	69	422	282	26	308
Illinois	428,569	38,156	466,725	3,353,961	7,619	232	7,851	8,321	1,362	9,683	6,849	741	7,590
Iowa	22,394	7,663	30,057	104,863	825	10	835	787	58	845	523	24	547
Louisiana	100,504	37,181	137,685	448,276	2,620	257	2,877	3,968	408	4,376	2,175	140	2,315
Maryland	103,547	27,381	130,928	426,607	3,322	225	3,547	2,809	718	3,527	1,950	311	2,261
Mississippi	5,963	3,051	9,014	25,631	109	......	109	207	9	216	175	3	178
New York	207,517	15,053	222,570	930,315	4,165	317	4,482	4,031	1,315	5,346	3,346	595	3,941
Ohio	172,508	59,306	231,814	842,395	2,881	213	3,094	3,771	672	4,443	3,074	394	3,468
Rhode Island	39,822	12,423	52,245	287,410	1,425	16	1,441	1,395	57	1,452	1,245	19	1,264
Tennessee	54,275	14,597	68,872	236,019	1,045	103	1,148	1,752	123	1,875	1,358	50	1,408
Virginia	31,099	5,374	36,473	155,726	1,013	43	1,056	1,524	68	1,592	1,038	29	1,067
Wisconsin	144,622	25,863	170,485	483,565	2,647	88	2,735	1,608	557	2,165	1,432	207	1,639
Total	$1,534,346	$291,096	$1,825,442	$9,288,439	33,017	1,683	34,700	37,984	5,818	43,802	28,619	2,713	31,332

SUMMARY OF CAPITAL INVESTED, TAXES AND RENT PAID, AND PERSONS ENGAGED IN THE LIQUOR TRAFFIC, BY STATES, FOR THE YEAR ENDING JUNE 30, 1896—(Continued).

States.	Number of Establishments.	Capital.							
		Owned.				Rented.			Aggregate.
		Real Estate.	Fixtures	Sundries.	Total.	Real Estate.	Fixtures.	Total.	
California	1,665	$ 657,100	$ 1,225,917	$ 5,432,973	$ 7,315,990	$16,765,547	$ 42,280	$16,807,827	$ 24,123,817
Connecticut	2,415	2,461,102	1,026,383	1,783,082	5,270,567	5,824,559	48,880	5,873,439	11,144,006
Delaware	305	223,125	44,760	168,590	436,475	244,950	....	244,950	681,425
Illinois	6,581	6,575,358	2,751,739	7,475,488	16,800,585	35,111,909	247,925	35,359,834	52,160,419
Iowa	611	439,482	180,377	564,317	1,184,176	945,145	9,905	955,050	2,139,226
Louisiana	2,430	1,463,672	407,485	1,885,315	3,756,472	4,319,495	12,141	4,331,636	8,088,108
Maryland	2,989	1,775,409	288,535	1,538,205	3,602,149	3,712,245	45,230	3,757,475	7,359,624
Mississippi	97	105,517	31,375	177,635	314,527	184,095	....	184,095	498,622
New York	3,914	7,031,276	1,930,909	4,643,546	13,605,821	11,219,108	49,048	11,268,156	24,873,977
Ohio	2,771	2,312,834	895,156	7,881,361	11,089,351	8,832,379	25,590	8,857,969	19,947,320
Rhode Island	1,226	658,570	429,920	1,080,233	2,168,723	2,184,391	10,505	2,194,896	4,363,619
Tennessee	872	763,162	362,872	1,550,784	2,676,818	2,230,412	18,345	2,248,757	4,925,575
Virginia	871	642,515	199,400	1,061,795	1,903,710	1,562,685	2,300	1,564,985	3,468,695
Wisconsin	2,511	2,680,648	419,727	1,455,917	4,556,292	4,864,281	226,793	5,091,074	9,647,366
Total	29,258	$27,787,770	$10,194,645	$36,699,241	$74,681,656	$98,001,201	$738,942	$98,740,143	$173,421,799

TOTAL ANNUAL REVENUE DERIVED FROM LIQUOR MANUFACTURE A TRAFFIC (FOR THE YEAR ENDING JUNE 30, 1896).

Tax on real and personal property employed in liquor manufacture (estimated)	$ 1,225,80
Tax on real and personal property employed in liquor traffic (estimated)	10,075,12
Ad valorem tax in Kentucky and Missouri	32,11
United States internal revenue tax	114,450,86
License fees or special taxes, states	10,399,01
License fees or special taxes, counties	5,011,22
License fees or special taxes, municipalities	34,155,29
Fines, states	91,29
Fines, counties	378,55
Fines, municipalities	533,91
Fines, sales of confiscated liquors, etc., United States (estimated)	123,84
Customs duties on imported liquors	6,736,06
Total	$183,213,12

FINANCIAL IMPORTANCE OF LIQUOR TRAFFIC.

With respect to the table giving a summary of capital invest taxes and rent paid and persons engaged in the liquor traffic. states (see pages 1126 and 1127), the Commissioner of Labor say

It is impracticable to give estimates of the capital, employ etc., representing the liquor traffic in each state and territo Such estimates would have to be based on average conditions all the states canvassed and would not correctly represent the dividual states and territories where widely varying conditic are known to exist. This may be seen by an examination of table. But the facts given in this table, covering as they do canvass of parts of 14 states and including nearly one-fifth the entire number of establishments in the country, are believ to be fairly representative of the whole country. And it is lieved that an estimate for the 161,483 establishments in whole country, if based on an average of the facts shown in t table, will be substantially accurate. Estimates have thus be made.

For the year ending June 30, 1896, the capital invested c clusively in the liquor traffic by the 161,483 establishments estimated by the method just described was $957,162,907. this amount $412,188,729, or 43.06 per cent, represented the val of land and buildings, fixtures and other properties owned the persons or firms carrying on the liquor traffic, and $544,97 178, or 56.94 per cent, the value of the property rented by the The estimated annual taxes paid on the property was $10,075,1 and the rent paid on the rented property $51,265,465. For

reason heretofore given the estimated amount of taxes should not be used as a basis to estimate the rate of taxation, or the estimated rent as the basis to ascertain the per cent of return on rented property used in the liquor traffic. All of these values pertain exclusively to the liquor traffic and not to any other business that may be conducted by the different establishments. The estimated number of proprietors or firm members engaged in the liquor traffic was 191,519 and the employes 241,755. If the employes had devoted their entire time to the liquor traffic, it is estimated that it would have required 172,931 to carry on the business of the 161,483 establishments.

INTERNAL REVENUE RECEIPTS FROM FERMENTED LIQUORS, JULY 1, 1898, TO JUNE 30, 1900.

Objects of Taxation.	Receipts during fiscal years ended June 30—		Increase.	Decrease.
	1899.	1900.		
Ale, beer, lager beer, porter, and other similar fermented liquors	67,673,301.31	72,762,070.56	5,068,769.25	....
Brewers (special tax)	179,357.40	161,308.52	....	18,048 88
Retail dealers in malt liquors (special tax)	232,399 56	239,833.81	7,434.25	....
Wholesale dealers in malt liquors (special tax)	382,409.34	372,780.59	....	9,628.75
Additional collections on fermented liquors stored in warehouse, act of June 13, 1898	177,090.84	14,761.01	....	162,329.83
Total	68,644,558.45	73,550,754.49	4,906,196 04	....

PRODUCTION OF FERMENTED LIQUORS IN THE SEVERAL STATES AND TERRITORIES OF THE UNITED STATES FOR THE FISCAL YEAR ENDED JUNE 30, 1900.

States and Territories.	Barrels.	States and Territories.	Barrels.
Alabama	63,090	Montana	201,940
Arkansas	11,505	Nebraska	238,848
California	753,582	New Hampshire	294,076
Colorado	275,549	New Jersey	2,150,684
Connecticut	739,064	New Mexico	4,048
Florida	7,785	New York	9,923,108
Georgia	113,380	North Carolina	....
Hawaii	......	Ohio	3,049,958
Illinois	3,809,710	Oregon	332,511
Indiana	847,962	Pennsylvania	4,683,025
Iowa	245,603	South Carolina	5,985
Kansas	8,965	Tennessee	136,143
Kentucky	494,006	Texas	349,066
Louisiana	230,083	Virginia	139,947
Maryland	1,025,028	West Virginia	155,068
Massachusetts	1,802,736	Wisconsin	3,357,738
Michigan	907,156		
Minnesota	706,280	Total	39,330,849
Missouri	2,461,252		

STATEMENT OF FERMENTED LIQUORS REMOVED FROM BREWERIES BOND, FREE OF TAX, FROM JULY 1, 1899, TO JUNE 30, 1900, UNDER ACT OF JUNE 18, 1890.

	Gallo
Removed for export and unaccounted for June 30, 1899.	460.
Removed for direct exportation......................	739.
Removed in original packages, to be bottled for export.	2,321.
Removed by pipe line, to be bottled for export........	1,300,
Excess reported by bottlers..........................	10,
Total	4,831,
Exported in original packages, proofs received........	780,
Exported in bottles, proofs received..................	3,469,
Removed for export, unaccounted for, tax paid........	8,
Excess reported by bottlers	60,
Removed for export, unaccounted for, June 30, 1900....	512,
Total	4,831,

FERMENTED LIQUORS REMOVED FROM BREWERIES IN BOND FOR EXP DURING THE YEAR ENDED JUNE 30, 1900, BY DISTRICTS.

District.	Gallons.	District.	Gallon
Alabama	18,724	First New York	426
First California	174,322	Second New York	30
Fourth California	29,398	Third New York	81
Connecticut	4,579	Fourteenth New York	172
Florida	51,290	Twenty-eighth New York	29
Georgia	106,187	First Ohio	26
First Illinois	12,970	Eleventh Ohio	4
Sixth Indiana	21,159	Oregon	354
Seventh Indiana	1,441	South Carolina	10
Fifth Kentucky	39,339	Fifth Tennessee	16
Sixth Kentucky	25,513	Third Texas	79
Louisiana	16,818	Second Virginia	
Third Massachusetts	438	Sixth Virginia	1
First Missouri	1,010,205	First Wisconsin	1,473
Montana	1,395		
Fifth New Jersey	51,265	Total	4,361

INTERNAL REVENUE RECEIPTS FROM FERMENTED LIQUORS, AND QUA TITIES PRODUCED, 1862 TO 1900.

The table on the next page shows the internal revenue recei from fermented liquors at one dollar and two dollars per bar and at sixty cents per barrel, together with the quantities of *same* on which tax was paid during each fiscal year, from Septe *ber 1, 1862*, to June 30, 1900.

Prior to September 1, 1866, the tax on fermented liquors w

paid in currency, and the full amount of tax was returned by collectors. From and after that date the tax was paid by stamps, on which a deduction of 7½ per cent was allowed to brewers using them. The Act of July 24, 1897, repealed the 7½ per cent discount. The Act of June 13, 1898, increased the tax to $2 per barrel, and restored the 7½ per cent discount.

Fiscal Years Ended June 30.	Rates of Tax.	Aggregate Collections at Each Rate.	Aggregate Quantities at Each Rate.	Aggregate Collections for Each Fiscal Year.	Aggregate Quantities in Barrels and Their Equivalents in Gallons for Each Fiscal Year. 31 Gallons Per Barrel.	
			Barrels.		Barrels.	Gallons.
1863....	$1.00	$ 885,271.88	885,272	$ 1,558,083.41	2,006,625	62,205,375
	.60	672,811.53	1,121,353			
1864 ...	.60	1,376,491.12	2,294,152	2,223,719.73	3,141,381	97,382,811
	1.00	847,228.61	847,229			
1865......	1.00	3,657,181.06	3,657,181	3,657,181.06	3,657,181	113,372,611
1866......	1.00	5,115,140.49	5,115,140	5,115,140.49	5,115,140	158,569,340
1867	1.00	5,819,345.49	6,207,402	5,819,345.49	6,207,402	192,429,462
1868	1.00	5,685,663.70	6,146,663	5,685,663.70	6,146,663	190,546,553
1869......	1.00	5,866,400.98	6,342,055	5,866,400.98	6,342,055	196,603,705
1870......	1.00	6,081,520.54	6,574,617	6,081,520.54	6,574,617	203,813,127
1871......	1.00	7,159,740.20	7,740,260	7,159,740.20	7,740,260	239,948,060
1872......	1.00	8,009,969.72	8,659,427	8,009,969.72	8,659,427	268,442,237
1873......	1.00	8,910,823.83	9,633,323	8,910,823.83	9,633,323	298,633,013
1874 ...	1.00	8,880,829.68	9,600,897	8,880,829.68	9,600,897	297,627,807
1875......	1.00	8,743,744.62	9,452,697	8,743,744.62	9,452,697	293,033,607
1876......	1.00	9,159,675.95	9,902,352	9,159,675.95	9,902,352	306,972,912
1877......	1.00	9,074,305.93	9,810,060	9,074,305.93	9,810,060	304,111,860
1878......	1.00	9,473,360.70	10,241,471	9,473,360.70	10,241,471	317,485,601
1879......	1.00	10,270,352.83	11,103,084	10,270,352.83	11,103,084	344,195,604
1880......	1.00	12,346,077.26	13,347,111	12,346,077.26	13,347,111	413,760,441
1881......	1.00	13,237,700.63	14,311,028	13,237,700.63	14,311,028	443,641,868
1882......	1.00	15,680,678.54	16,952,085	15,680,678.54	16,952,085	525,514,635
1883......	1.00	16,426,050.11	17,757,892	16,426,050.11	17,757,892	550,494,652
1884......	1.00	17,573,722.88	18,998,619	17,573,722.88	18,998,619	588,957,189
1885......	1.00	17,747,006.11	19,185,953	17,747,006.11	19,185,953	594,764,543
1886......	1.00	19,157,612.87	20,710,933	19,157,612.87	20,710,933	642,038,923
1887......	1.00	21,387,411.79	23,121,526	21,387,411.79	23,121,526	716,767,306
1888......	1.00	22,829,202.90	24,680,219	22,829,202.90	24,680,219	765,086,789
1889.....	1.00	23,235,863.94	25,119,853	23,235,863.94	25,119,853	778,715,443
1890......	1.00	25,494,798.50	27,561,944	25,494,798.50	27,561,944	854,420,264
1891......	1.00	28,192,327.69	30,478,192	28,192,327.69	30,478,192	944,823,952
1892.....	1.00	29,431,498.06	31,817,836	29,431,498.06	31,817,836	986,352,916
1893 ...	1.00	31,962,743.15	34,554,317	31,962,743.15	34,554,317	1,071,183,827
1894......	1.00	30,834,674.01	33,334,783	30,834,674.01	33,334,783	1,033,378,273
1895......	1.00	31,044,304.84	33,561,411	31,044,304.84	33,561,411	1,040,403,741
1896......	1.00	33,139,141.10	35,826,098	33,139,141.10	35,826,098	1,110,609,038
1897.....	1.00	31,841,362.40	34,423,094	31,841,362.40	34,423,094	1,067,115,914
1898 ..	1.00	34,480,524.23	35,112,426	38,885,151.63	37,493,306	1,162,292,486
	2.00	4,404,627.40	2,380,880			
1899....	1.00	2,070.31	2,070	67,673,301.31	36,581,114	1,134,014,534
	2.00	67,671,231.00	36,579,044			
Total.	......	$643,810,488.58	655,151,949	$643,810,488.58	655,151,949	20,309,710,419
1900......	......	....	....	72,776,831.57	39,330,849	1,219,256,319
G'd Total	......	....	....	716,587,320.15	694,482,798	21,528,966,738

VALUE OF BARLEY IN THE UNITED STATES PER ACRE, 1890 TO 1899, FROM YEAR-BOOK OF THE UNITED STATES DEPARTMENT OF AGRICULTURE.

States and Territories.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	189
Maine.........	$15.20	$19.08	$15.16	$17.49	$17.23	$16.85	$13.16	$13.75	$15.12	$17.
New Hampshire........	16.20	19.46	17.39	17.71	15.37	14.34	15.53	13.50	13.63	16.
Vermont......	15.75	19.66	17.16	16.50	16.74	15.60	13.53	13.11	14.10	16.
Massachusetts	16.94	20.03	16.87	22.77	13.67	14.63	17.40	22.77	16.17	20.
Rhode Island.	16.49	21.84	17.63	21.92	21.60	17.63	17.40	15.12	17.08	20.
New York ..	13.03	15.15	16.65	12.18	9.80	18.55	9.05	10.50	12.10	12.
Pennsylvania.	14.70	14.40	12.37	9.50	7.97	8.28	6.88	9.55	8.54	10.
Texas.........	9.72	11.86	10.73	8.99	8.41	11.66	6.00	10.75	10.00	11.
Tennessee	13.61	6.86	12.87	8.31	7.73	11.55	6.30	10.62	10.08	7.
Kentucky.....	12.42	13.23	8.47	8.67	13.49	12.65	5.92	8.00	6.40	9.
Ohio...........	13.65	15.42	13.39	10.67	13.68	11.56	7.68	11.69	12.63	12.
Michigan......	14.05	14.70	14.04	8.04	10.30	7.78	9.37	8.60	11.09	11.
Indiana	10.72	13.87	14.56	8.95	9.32	6.00	6.70	8.36	10.30	11.
Illinois........	12.18	14.30	8.77	9.28	11.28	9.00	7.35	9.50	10.65	13.
Wisconsin....	13.17	14.57	12.75	10.32	12.87	9.96	7.40	8.96	11.64	12.
Minnesota. ...	12.37	11.74	12.31	7.96	9.63	8.64	5.44	6.12	9.37	7.
Iowa	11.75	11.47	8.44	7.46	6.51	6.44	5.52	5.76	8.84	8.
Missouri......	11.40	14.71	12.22	8.00	7.14	7.34	4.38	7.60	7.20	7.
Kansas........	10.26	10.60	8.75	3.81	4.31	3.31	1.01	4.38	7.56	4.
Nebraska. ..	9.86	10.06	7.33	3.72	2.45	6.82	3.78	5.28	6.78	7.
South Dakota.	10.14	11.68	8.16	5.08	4.72	3.71	5.42	4.40	6.21	6.
North Dakota		12.60	8.02	4.71	7.24	6.08	3.38	6.07	7.66	7.
Montana......	17.76	19.50	21.45	15.05	9.00	14.75	13.75	19.00	20.52	17.
Colorado..	18.62	14.84	12.96	14.15	16.04	18.78	9.20	14.28	14.03	15.
New Mexico..	12.96	15.40	12.74	12.53	18.90	19.04	12.35	17.88	18.59	19.
Utah..........	17.40	16.02	10.56	16.92	15.18	11.70	11.38	13.95	17.39	17.
Idaho..........	15.75	19.72	8.58	15.90	15.32	10.29	3.37	14.70	16.80	16.
Washington..	17.00	18.90	11.39	15.64	10.78	14.17	10.40	19.35	17.91	15.
Oregon........	17.50	11.52	10.72	10.44	12.74	8.84	9.81	14.63	14.26	14.
California.....	16.72	14.46	11.28	9.45	6.84	8.12	10.37	12.42	6.82	13.
Gen'l average.	13.44	13.56	11.18	8.92	8.56	8.88	7.02	9.25	8.93	10.

IMPORTATION OF FOREIGN BARLEY FOR THE LAST 10 FISCAL YEARS

	Bushels.	Value.	Duty.	Ad valorem rate of duty
1890.............	11,332,545	$5,629,849	$1,133,255	20.11
1891.............	5,078,733	3,322,593	1,500,640	45.16
1892.............	3,146,328	1,592,040	943,898	59.28
1893.............	1,970,129	921,605	591,039	64.13
1894.............	791,061	358,744	237,318	66.15
1895.............	2,116,816	867,743	Cannot be determined	
1896.............	837,384	317,209	95,163	30.00
1897.............	1,271,787	304,749	118,425	30.00
1898.............	124,804	43,863	37,441	85.35
1899.............	110,475	53,696	33,143	61.72

[redacted]

AVERAGE YIELD OF BARLEY PER ACRE FOR THE 10 YEARS, 1890 TO 1899. —FROM YEAR-BOOK OF THE UNITED STATES DEPARTMENT OF AGRICULTURE.

States and Territories.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.
	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.
Maine	20.0	26.5	22.3	26.1	26.1	32.4	30.6	25.0	27.0	29.0
New Hampshire	20.0	26.3	23.5	25.3	24.4	25.6	29.3	22.5	23.5	25.0
Vermont	22.5	27.3	26.0	27.5	27.9	33.2	33.0	28.5	30.0	31.0
Massachusetts	22.0	26.7	22.5	25.3	21.7	22.5	30.0	34.5	24.5	30.0
Rhode Island	21.7	28.0	21.5	25.2	30.0	23.5	29.0	28.0	28.0	29.0
New York	16.7	23.3	22.2	20.3	17.5	22.9	23.2	25.0	25.2	24.0
Pennsylvania	....	22.5	21.7	19.0	16.6	20.2	17.2	24.5	19.4	21.0
Texas	15.0	15.2	16.5	14.5	15.3	21.6	12.0	25.0	20.0	18.0
Tennessee	....	12.7	19.5	15.1	13.8	23.1	14.0	18.0	18.0	11.0
Kentucky	19.0	24.5	22.3	17.0	28.7	33.3	14.8	20.0	16.0	21.0
Ohio	19.5	25.7	23.5	22.7	28.5	28.2	20.2	28.5	28.7	28.0
Michigan	22.3	24.5	23.4	16.4	20.6	18.1	22.3	21.5	25.2	24.0
Indiana	16.5	23.5	28.0	19.9	20.7	15.0	20.3	19.0	23.4	25.0
Illinois	20.3	26.0	17.9	23.2	23.5	20.0	23.7	25.0	27.3	29.0
Wisconsin	22.7	26.5	25.5	24.0	28.6	29.3	27.4	28.0	29.1	30.0
Minnesota	22.5	27.3	24.9	22.1	23.5	36.0	27.2	25.5	28.4	25.0
Iowa	22.6	27.3	21.1	22.6	15.5	28.0	26.3	24.0	26.0	26.0
Missouri	20.0	.....	29.1	20.0	14.0	15.3	17.5	19.0	20.0	18.0
Kansas	18.0	26.5	25.0	8.1	8.8	14.4	14.6	17.5	28.0	17.0
Nebraska	17.3	27.2	22.2	12.0	5.7	28.4	19.9	22.0	27.1	26.0
South Dakota	19.5	28.5	23.3	15.4	14.7	19.5	28.5	20.0	23.0	23.0
North Dakota		30.0	24.3	15.2	20.1	30.4	16.1	22.5	26.4	24.0
Montana	24.0	30.0	32.5	30.1	22.5	25.0	25.0	38.0	36.0	35.0
Colorado	24.5	26.5	24.0	28.3	27.8	31.3	20.0	28.0	30.5	28.0
New Mexico	20.0	22.0	19.6	21.6	27.0	28.0	19.0	32.5	33.8	32.0
Utah	23.2	26.7	20.3	37.6	33.0	30.0	27.1	31.0	37.0	33.0
Idaho	....	29.0	26.0	30.0	32.6	24.5	15.3	35.0	35.0	35.0
Washington	25.0	31.5	25.3	40.1	33.7	37.3	26.0	45.0	39.8	35.0
Oregon	25.0	24.0	23.3	26.1	38.6	22.1	21.8	32.5	29.1	28.0
California	22.3	23.7	24.0	22.5	15.2	20.3	21.6	23.0	10.5	26.0
General average	21.00	25.80	23.70	21.70	19.37	26.30	23.62	24.52	21.60	25.50

EXPORTATION OF DOMESTIC BARLEY FOR THE LAST 10 FISCAL YEARS.

	Bushels.	Value.
1890	1,408,311	$754,605
1891	973,062	669,203
1892	2,800,075	1,751,445
1893	3,035,267	1,468,843
1894	5,219,405	2,379,714
1895	1,563,754	767,228
1896	7,680,331	3,100,311
1897	20,030,301	7,646,384
1898	11,237,077	5,542,040
1899	2,267,403	1,375,27[illegible]

Of the domestic barley exported in 1899, 961,894 bushels, the value of $594,589, were shipped from San Francisco, Ca 980,474 bushels, of the value of $596,650, from New York, N. Y and the balance, 325,035 bushels, of the value of $184,035, fro all other ports.

The United Kingdom (Great Britain and Ireland) receiv 1,220,560 bushels, of the value of $752,590; Germany, 152,8 bushels, of the value of $69,509; Belgium, 152,459 bushels, the value of $105,770; the Hawaiian Islands, 511,842 bushels, the value of $300,843; and all other countries, 229,681 bushels, the value of $146,562.

PRICES OF BARLEY PER BUSHEL ON THE FARM DECEMBER 1, 1890 1899.—FROM YEAR-BOOK OF THE UNITED STATES DEPARTMENT OF AGRICULTURE.

States and Territories	1890	1891	1892	1893	1894	1895	1896	1897	1898	18
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Ct
Maine	76	72	68	67	66	52	43	55	56	
New Hampshire	81	74	74	70	63	56	53	60	58	
Vermont	70	72	66	60	60	47	41	46	47	
Massachusetts	77	75	75	90	63	65	58	66	68	
Rhode Island	76	78	82	87	72	75	60	54	61	
New York	78	65	75	60	56	81	39	42	48	
Pennsylvania	70	64	57	50	48	41	40	39	44	
Texas		78	65	62	55	54	50	43	50	
Tennessee	....	....	68	55	56	50	45	50	56	
Kentucky	....	....	38	51	47	38	40	40	40	
Ohio	70	60	57	47	48	41	38	41	44	
Michigan	63	60	60	49	50	43	42	40	44	
Indiana	65	59	52	45	45	40	33	44	44	
Illinois	60	55	49	40	48	45	31	38	39	
Wisconsin	58	55	50	43	45	34	27	32	40	
Minnesota	55	43	42	36	41	24	20	24	33	
Iowa	52	42	40	33	42	23	21	24	34	
Missouri	57	57	42	40	51	48	25	40	36	
Kansas	57	40	35	47	49	23	22	25	27	
Nebraska	57	37	33	31	43	24	19	24	25	
South Dakota	52	41	35	33	35	19	19	22	27	
North Dakota		42	33	31	36	20	21	27	29	
Montana	74	65	66	50	40	59	55	59	57	
Colorado	76	56	54	50	58	60	26	51	46	
New Mexico	....	70	65	58	70	68	65	55	55	
Utah	75	60	52	45	46	30	42	45	47	
Idaho	75	68	33	53	47	42	22	42	48	
Washington	68	60	45	39	32	38	40	43	45	
Oregon	70	48	46	40	33	40	45	45	49	
California	75	61	47	42	45	40	48	54	65	
General average	64 86	54 00	47 20	41 12	44 19	33 66	32 27	37 70	41.34	0.

BARLEY CROPS OF DIFFERENT COUNTRIES IN BUSHELS.—FROM YEAR-BOOK OF THE DEPARTMENT OF AGRICULTURE.

Countries.	1895.	1896.	1897.	1898.	1899.
	Bushels.	Bushels.	Bushels.	Bushels.	Bushels.
United States	87,073,000	69,695,000	66,685,000	55,792,000	73,382,000
Ontario	12,471,000	13,069,000	12,401,000	13,063,000	15,298,000
Manitoba	5,823,000	3,272,000	3,284,000	4,413,000	5,549,000
Rest of Canada	2,400,000	2,500,000	2,400,000	2,900,000	2,950,000
Total Canada	20,694,000	18,841,000	18,085,000	20,376,000	23,797,000
Total North America	107,767,000	88,536,000	84,770,000	76,168,000	97,179,000
Great Britain	70,814,000	73,005,000	68,920,000	70,197,000	69,850,000
Ireland	6,579,000	7,272,000	5,982,000	6,889,000	7,061,000
Total United Kingdom	77,393,000	80,277,000	74,902,000	77,086,000	76,911,000
Sweden	14,618,000	14,390,000	14,303,000	14,805,000	11,691,000
Denmark	21,794,000	21,249,000	19,172,000	21,868,000	21,000,000
Netherlands	4,291,000	4,561,000	3,736,000	5,000,000	4,000,000
Belgium	3,900,000	3,987,000	3,457,000	4,000,000	3,700,000
France	48,283,000	46,088,000	41,157,000	46,878,000	47,782,000
Italy	7,435,000	10,057,000	7,700,000	8,900,000	8,000,000
Germany	130,549,000	127,117,000	119,580,000	132,019,000	139,241,000
Austria	59,092,000	54,818,000	49,756,000	60,044,000	58,740,000
Hungary	52,456,000	57,842,000	41,290,000	54,774,000	54,731,000
Croatia-Slavonia	2,413,000	3,021,000	2,143,000	3,373,000	3,201,000
Total Austria-Hungary	113,961,000	115,681,000	93,189,000	118,191,000	116,672,000
Roumania	22,388,000	31,787,000	21,225,000	29,656,000	4,543,000
Bulgaria	16,000,000	20,000,000	11,000,000	13,000,000	10,000,000
Russia proper	210,222,000	208,449,000	203,363,000	254,702,000	179,850,000
Poland	15,912,000	16,744,000	15,967,000	19,480,000	20,090,000
North Caucasus	20,397,000	19,286,000	11,120,000	25,107,000	18,144,000
Total Russia in Europe	246,531,000	244,479,000	230,450,000	299,289,000	218,084,000
Total Europe	707,143,000	719,673,000	639,871,000	770,692,000	661,624,000
Siberia	4,833,000	6,001,000	6,119,000	4,904,000	5,955,000
Central Asia	1,490,000	3,149,000	2,081,000	2,728,000	2,870,000
Total Russia in Asia	6,323,000	9,150,000	8,200,000	7,632,000	8,825,000
Japan	43,700,000	40,180,000	41,099,000	44,059,000	44,000,000
Total Asia	50,023,000	49,330,000	49,299,000	51,691,000	52,825,000
Algeria	38,637,000	31,094,000	20,000,000	37,000,000	20,000,000
Tunis	8,000,000	4,000,000	5,000,000	11,000,000	6,000,000
Cape Colony	686,000	690,000	793,000	937,000	900,000
Total Africa	47,323,000	35,784,000	25,793,000	48,937,000	26,900,000
West Australia	15,000	19,000	13,000	24,000	30,000
South Australia	121,000	92,000	111,000	167,000	1,241,000
Queensland	39,000	8,000	20,000	52,000	36,000
New South Wales	185,000	99,000	114,000	103,000	66,000
Victoria	1,647,000	738,000	841,000	782,000	1,148,000
Tasmania	209,000	143,000	77,000	72,000	190,000
New Zealand	1,032,000	1,069,000	848,000	732,000	1,731,000
Total Australasia	3,248,000	2,168,000	2,024,000	1,932,000	3,442,000
Total	915,504,000	895,491,000	801,757,000	949,420,000	841,970,000

IMPORTS OF BARLEY MALT FOR THE LAST 10 FISCAL YEARS.

	Bushels.	Value.	Ad valo rate of d
1890	217,586	$161,666	26
1891	123,083	78,433	21.
1892	5,165	6,148	37.
1893	3,559	4,411	36.
1894	5,070	5,676	39.
1895	11,069	7,495	Cannot determi
1896	5,579	4,774	40.
1897	11,084	9,384	40.
1898	4,769	4,412	45.
1899	4,984	4,447	45.

The importation, owing to the high duty, has decreased si 1891 to such an extent that it has almost disappeared as a fac in the brewing interest.

IMPORTS OF GRANULATED RICE, MEAL AND RICE FLOUR, FOR THE L 10 FISCAL YEARS.

	Pounds.	Value.	D
1890	55,667,174	$ 927,067	$185
1891	81,259,519	1,389,408	.....
1892	62,991,524	1,097,436	157.
1893	66,451,884	1,191,526	166.
1894	55,351,281	833,843	138.
1895	78,262,909	1,091,538	195.
1896	68,534,273	911,005	171.
1897	63,876,204	961,200	150.
1898	60,474,685	953,722	151.
1899	50,340,267	777,378	125.

IMPORTS OF FOREIGN HOPS FOR THE LAST 10 FISCAL YEARS.

	Pounds.	Value.	Duty.	Ad valorem r of d
1890	6,539,516	$1,053,616	$523,161	49.
1891	4,019,603	1,797,406	588,196	32.
1892	2,506,224	883,701	375,934	42
1893	2,691,244	1,085,407	403,687	39.
1894	828,022	484,415	124,203	25.
1895	3,133,664	599,744	Cannot be determi	
1896	2,772,045	600,419	221,764	36.
1897	3,017,821	629,987	241,425	38.
1898	2,375,922	648,155	285,111	43.
1899	1,319,319	591,755	158,318	

EXPORTS OF DOMESTIC HOPS FOR THE LAST 10 FISCAL YEARS.

	Pounds.	Value.
1890	7,540,854	$1,110,571
1891	8,736,080	2,327,474
1892	12,604,686	2,420,502
1893	11,367,030	2,695,867
1894	17,472,975	3,844,232
1895	17,523,388	1,872,597
1896	16,765,254	1,478,919
1897	11,426,241	1,304,183
1898	17,161,669	2,642,779
1899	21,145,512	3,626,144

Of the domestic hops exported in 1899, 18,964,836 pounds, of the value of $3,291,347, were shipped to the United Kingdom; 464,013 pounds, of the value of $61,389, to the Dominion of Canada, Newfoundland and Labrador; 838,069 pounds, of the value of $124,673, to British Australasia and the British East Indies; and 17,951 pounds, of the value of $2,362 to Mexico; and 705,171 pounds, of the value of $124,136 to Belgium. All other countries received only 155,472 pounds, of the value of $22,237.

HOP CROPS OF DIFFERENT COUNTRIES, 1895 TO 1899, IN BALES OF 180 POUNDS.—FROM YEAR-BOOK OF THE UNITED STATES DEPARTMENT OF AGRICULTURE.

[In bales of 180 pounds.]

Countries.	1895.	1896.	1897.	1898.	1899.
California	52,000	35,000	45,000	41,500	64,000
Oregon	99,500	56,000	75,000	71,250	85,000
Washington	28,800	12,000	32,000	36,200	33,000
New York	110,000	75,000	75,000	65,000	58,000
Total United States	290,300	178,000	227,000	216,950	240,000
Australia	....	....	18,383	18,383	a7,218
Austria-Hungary	95,000	136,000	100,000	95,000	190,633
Belgium	....	....	85,734	30,630	b70,311
England	343,000	281,000	255,784	218,000	411,554
France	42,000	43,000	88,184	42,867	25,545
Germany	368,000	353,000	584,498	440,920	407,199
Russia	....	....	64,000	61,240	41,057
Total	1,138,300	991,000	1,423,583	1,123,990	1,393,517

a New Zealand only. *b* Belgium and the Netherlands.

NUMBER AND VALUE OF STAMPS FOR FERMEN
NUMBER OF BREWERS' PERMITS ISS

Denomination.	Number Issued In					
	July.	Aug.	Sept.	Oct.	Nov.	D
Hogshead	32,500	128,000	98,000	163,000	66,000	1
Barrel	633,500	857,000	1,137,200	471,400	432,000	5
One-half barrel	3,566,000	5,368,000	3,937,000	3,038,000	2,746,000	2,3
One-third barrel	......	21,000	78,000	....	21,000	
One-quarter barrel	1,985,000	2,532,000	2,157,000	2,017,000	1,540,000	1,0
One-sixth barrel	87,000	201,000	117,000	48,000	135,200	
One-eighth barrel	500,500	790,000	700,000	430,500	500,080	3
Total	6,864,500	9,897,000	8,224,200	6,167,900	5,440,280	4,51
Exportation	10,400	7,600	12,000	23,600	12,400	1
Brewers' permits	800	....	6,000	20,000	....	...

NUMBER OF BREWERS AND DEALERS IN MA LIQUORS, BY STATES, FOR THE YEAR ENDED JUNE 30, 1900.

States and Territories.	Brewers.	Retail Dealers in Malt Liquors.	Wholesale Dealers in Malt Liquors.
Alabama	5	219	28
Alaska	16	1	1
Arizona	2	10	37
Arkansas	1	56	33
California	128	265	190
Colorado	21	149	122
Connecticut	21	121	145
Delaware	5	41	15
Dis. of Columbia	5	50	20
Florida	1	75	20
Georgia	5	165	34
Hawaii	...	....	...
Idaho	18	13	20
Illinois	121	1,281	553
Indiana	47	633	344
Indian Territory	.....	58	5
Iowa	23	465	465
Kansas	3	280	80
Kentucky	29	215	32
Louisiana	9	30	71
Maine	5	290	20
Maryland	28	107	74
Massachusetts	50	270	385
Michigan	90	417	324
Minnesota	94	663	507
Mississippi	....	22	20
Missouri	51	525	366
Montana	23	86	36

States and Territories.	Brewers.	Retail Dealers in Malt Liquors.
Nebraska	23	196
Nevada	6	2
New Hampshire	5	190
New Jersey	49	296
New Mexico	2	9
New York	269	519
North Carolina	......	85
North Dakota	......	90
Ohio	132	430
Oklahoma	....	53
Oregon	29	44
Pennsylvania	227	811
Rhode Island	8	18
South Carolina	1	51
South Dakota	6	70
Tennessee	4	55
Texas	11	2,298
Utah	7	28
Vermont	......	222
Virginia	7	94
Washington	33	58
West Virginia	8	101
Wisconsin	171	520
Wyoming	5	51
Total	1,816	12,716
Tot. for fiscal year ended June 30, 1899	1,960	12,2[illegible]

LIQUORS (TAX PAID AND EXPORTATION) AND THE DURING THE YEAR ENDED JUNE 30, 1900.

	Number Issued In					Aggregate Number of Each Denomination.	Aggregate Value of Each Denomination.
Jan.	Feb.	March.	April.	May.	June.		
146,000	74,000	66,000	160,500	129,000	54,000	1,259,000	$ 5,036,000.00
467,300	707,500	381,500	999,200	546,500	967,000	8,268,600	16,537,200.00
2,535,500	3,414,000	2,248,000	4,381,000	3,954,500	5,895,500	43,466,500	43,466,500.00
....	24,000	30,000	60,000	24,000	3,000	264,000	176,000.00
1,535,000	1,560,000	814,000	3,220,600	1,508,000	3,240,000	23,154,000	11,577,000.00
86,400	54,000	60,600	137,300	115,800	112,200	1,176,100	392,033.34
421,380	384,000	226,500	712,800	310,500	1,044,200	6,846,540	1,586,635.00
5,191,580	6,217,500	3,826,600	9,670,800	6,588,300	11,335,900	83,934,740	$78,771,368.34
....	6,400	8,000	46,000	7,600	6,800	156,000	....
....	1,200	8,800	....	20,000	2,800	59,600	....

BEER PRODUCTION OF THE WORLD ("GAMBRINUS").

1899.	Production of Beer.		Beer Tax. Dollars.	Tax Per Head. Dollars.	Malt Consumed. Bushesl.	Hops, Pounds.		Number of Breweries.
	Barrels.	Gal. Per Cap.				Consumed.	Produced.	
Austria-Hung'y.	18,144,000	.....	19,471,000	....	26,686,000	18,592,000	29,762,000	1,580
Germany	57,766,000	.....	26,647,000	0.24	81,380,000	46,593,000	59,625,000	20,055
Bavaria	14,867,000	73.9	10,249,000	1.5	25,718,000	17,948,000	32,848,000	6,218
Baden.........	2,511,000	26.9	2,183,000	1.1	4,090,000	1,953,000	4,960,000	897
Würtemberg ..	3,467,000	62.1	2,565,000	1.2	5,312,000	2,691,000	8,818,000	6,221
Balance of Empire.........	36,921,000	.....	11,650,000	....	46,250,000	24,002,000	13,005,000	6,719
Great Britain and Ireland...	52,114,000	41.5	72,061,000	1.3	134,278,000	74,461,000	72,862,000	6,891
United States of America.......	36,579,000	12.89	71,680,000	0.79	144,494,000	28,374,000	43,200,000	1,959
South America and Australia.	18,626,000	.....	48,680,000	...		40,710,000	1,223,000	431
Belgium....	11,785,000	39.0	4,328,000	0.53	10,931,000	8,215,000	9,370,000	3,118
Luxemburg	145,000	12.3	20,960	0.91	135,500	123,460	....	63
France........ ..	8,013,000	7.4	5,549,000	0.17	13,639,000	7,539,000	5,291,000	2,546
Russia	4,520,000	1.5	4,718,000	0.08	7,385,000	3,971,000	8,818,000	1,035
Denmark..	1,622,000	23.0	2,562,000	1.25	3,167,000	1,445,000	330,600	324
Netherlands.....	1,244,000	7.8	613,000	0.17	2,117,000	1,205,000	1,984,000	389
Spain............	76,865	0.3	47,200	0.17	199,600	105,300	....	36
Switzerland.....	1,805,000	12.9	no duty.	....	3,072,000	1,276,000	165,300	367
Sweden..........	1,763,000	11.0	no duty.	..	3,290,000	1,767,000	661,400	540
Norway	358,000	4.7	394,000	0.07	533,800	268,200		47
Italy	113,000	0.7	557,000	1.15	176,100	95,900	....	89
Roumania	95,426	0.9	263,000	0.67	169,800	90,610	....	21
Servia....	58,736	0.6	335,000	0.17	88,200	69,400	....	10
Bulgaria..........	68,386	0.6	90,200	0.14	121,800	92,600	....	23
Greece...........	71,700	0.7	363,000	0.14	113,362	58,900	....	10
Turkey (Europe)	13,806	0.05	no duty.	....	21,800	15,400	....	
	214,979,000	.....	257,707,000	....	431,993,000	230,068,000	233,308,000	39

MISCELLANEOUS INFORMATION.

In this chapter has been assembled a variety of information general character, and such as did not naturally fall under of the other chapter heads of the book.

It is believed that the tables of standard dimensions of brewery vessels will prove peculiarly valuable to brewers for quick reference. They were compiled from the Brewery Architects' Engineers' Hand-Book, by E. Schmidt.

The information relating to building materials, etc., was lar taken from Kidder's Architects' and Builders' Pocket-Book

STANDARD DIMENSIONS OF BREWERY VESSEL

MASH-TUB.

Number of Barrels in Cellar.	Contents of Mash-Tub in Barrels.	Diameter of Mash-Tub.	Height of Shell.	Height of Cover.	Grant. Diameter.	Grant. Length.	Wort Pipes. Number.	Wort Pipes. Diameter.	Sparger. Diameter of Ring.	Sparger. Diameter of Pipe.	Steam Inlets at Bottom. Number.	Steam Inlets at Bottom. Diameter.	Revolutions of Mashing Machine Per Minute.
		ft. in.	ft. in.	ft. in.	in.	ft. in.		in.	in.	in		in.	
25	60	8.6	4.6	1.9	15	3.0	4	1½	48	2½	4	1¼	22
35	80	10.0	4.6	2.0	15	4.0	6	1½	54	2½	4	1¼	19
50	110	11.0	5.0	2.0	15	4.0	6	1½	54	2½	4	1¼	18
75	130	12.0	5.0	2.0	15	4.0	6	1½	60	2½	4	1¼	16
100	155	12.0	6.0	2.0	18	4.6	6	2	60	2½	6	1¼	16
125	185	13.0	6.0	2.6	18	4.6	6	2	60	2½	6	1¼	15
150	215	14.0	6.0	2.6	18	4.6	6	2	64	2½	6	1½	14
175	235	14.0	6.6	2.6	20	6.0	8	2	64	2½	6	1½	14
200	270	15.0	6.6	2.9	20	6.0	8	2	66	2½	6	1½	13
250	330	16.0	7.0	2.9	20	6.0	8	2	66	2½	8	1½	12
300	370	17.0	7.0	3.0	20	6.0	8	2½	72	3	8	1½	12
350	395	17.6	7.0	3.0	20	6.0	8	2½	72	3	8	1½	11
400	420	18.0	7.0	3.0	20	7.0	10	2½	84	3	8	1½	11
450	465	19.0	7.0	3.3	20	7.0	10	2½	84	3	8	1½	10
500	515	20.0	7.0	3.6	20	7.0	10	2½	90	3	8	1½	10

STANDARD DIMENSIONS OF BREWERY VESSELS.

KETTLE.

Number of Barrels in Cellar.	Contents in Barrels, to Manhole.	Dimensions.				Diameter of Beer Outlet.	Steam.				Valves.		
		Largest Diameter.	Diameter at Bottom.	Height of Shell, to Bottom of Rim.	Height of Outside Bottom.		Steam Inlets. Number.	Steam Inlets. Diameter.	Diam. of Steam Outlet, One in Each Case.	Diam. of Pipe for Ring.	Diameter of Reducing Valve.	Diameter of Vacuum Valve.	Diameter of Safety Valve.
		ft. in.	ft. in.	ft. in.	ft. in.	in.		in.	in.	in.	in	in.	in.
25	31	6.6	5.0	4.0	1.9	3	2	1¼	1½	1½	1½	1	1
35	43.5	7.6	6.0	4 0	2.2	3	2	1¼	1½	1½	1½	1	1
50	59	8.6	7.0	4.0	2.8	3	2	1½	1½	2	2	1	1
75	88	9.6	7.9	5.0	2.10	4	2	1½	1½	2	2	1	1
100	120	10.6	8.6	5.6	3.1	4	4	1¼	1¾	2½	2½	1½	1½
125	152	11.0	8.11	6.6	3.2	4	4	1¼	1¾	2½	2½	1½	1½
150	177	11.6	9.4	7.0	3.4	4	4	1¼	1¾	2½	2½	1½	1½
175	210	12.0	9.8	7.6	3.5	5	4	1¼	1¾	2½	2½	1½	1½
200	237	12.6	10.1	8.0	3 6	5	4	1¼	1¾	2½	2½	1½	1½
250	296	13.6	10.6	8.9	3.6	5	4	1½	2	3	3	2	2
300	360	14.6	11.0	9.6	3.7½	6	4	1½	2	3	3	2	2
350	410	15.3	11 6	9.9	3.9	6	4	1½	2	3	3	2	2
400	470	16.0	12.0	10.3	4.0	6	4	1½	2	3	3	2	2
450	525	16 6	12.6	10.9	4.3	7	4	1¾	2¼	3½	3½	2½	2½
500	580	17.0	13.0	11.3	4.6	7	4	1¾	2¼	3½	3½	2½	2½

Number of Barrels in Cellar.	RICE TUB.							BAUDELOT COOLER.						
	Contents in Barrels.	Diameter.	Height.	Steam Inlets. Number.	Steam Inlets. Diameter.	Revolutions Per Minute.	Horse-Power Required.	Cooling Capacity in Barrels Per Hour.	Length of Ammonia and Water Pipes.	Number of Ammonia Pipes.	Number of Water Pipes.	Pan. Width.	Pan. Length.	Pan. Depth.
		ft. in.	ft. in.		in.				ft. in.			ft. in.	ft. in.	ft. in.
25	21	5.0	4.6	4	1¼	30	2½	16	8.0	8	16	4.0	10 0	1.0
35	33	6.0	5.0	4	1¼	25	3	20	10.0	8	16	4.0	12.0	1.0
50	40	6.0	6.0	4	1¼	25	3	25	12.6	8	16	4.0	15.0	1.0
75	70	8.0	6.0	4	1¼	18	3½	30	10.0	12	24	4.0	12.0	1.0
100	90	9.0	6.0	4	1½	16	4	37	12.6	12	24	4.0	15 0	1.0
125	98	9.0	6.6	4	1½	16	4½	45	15.0	12	24	4.0	18.0	1.3
150	105	9.0	7.0	4	1½	16	5	50	12.6	16	32	4.0	15.0	1.3
175	117	9.6	7.0	4	1½	15	7	60	15.0	16	32	4.0	18.0	1 3
200	130	10.0	7.0	6	1½	14	9	72	18.0	16	32	4.0	21.0	1.3
250	150	10.0	8.0	6	1½	14	10	90	18.0	20	40	4.0	21.0	1.3
300	180	11.0	8.0	6	1½	13	11	100	20.0	20	40	4.0	23.0	1.6
									Two	Coo	lers			
350	215	12.0	8.0	6	1½	12	12½	120	20 0	12	24	7.6	23.0	1.6
400	240	12.0	9.0	8	1½	12	14	128	16.0	16	32	7.6	19.0	1.6
450	283	13.0	9.0	8	1½	11	16	144	18.0	16	32	7.6	21.0	1.6
500	330	14.0	9.0	8	1½	10	18	160	20.0	16	32	7.6	23.0	1

STANDARD DIMENSIONS OF BREWERY VESSELS.

	HOP-JACK.									BEER TANK.		
	Round.					Square.						
				Over Sprinkler.								
Number of Barrels in Cellar.	Contents in Barrels.	Diameter.	Height.	Diameter of Ring.	Diameter of Pipe.	Contents in Barrels.	Length.	Width.	Height.	Contents in Barrels.	Diameter.	Height.
		ft. in.	ft. in.	ft. in.	in.		ft in.	ft. in.	ft. in.		ft. in.	ft. in.
25	32	6.0	5.0	3.0	2½	40	7.0	5.0	5.0	28	6.0	4.0
35	45	7.0	5.0	3 6	2½	48	7 0	6 0	5.0	36	7.0	4.0
50	65	8.6	5.0	4.0	2½	65	8.0	7.0	5.0	55	8.0	4.6
75	82	9.0	5.6	4.6	2½	83	8.0	8 0	5.6	83	9.0	5.6
100	110	10.0	6.0	5.0	2½	110	10.0	8.0	5.6	112	10.0	6.0
125	135	11.0	6.0	5.6	2½	140	12.0	8.0	6 0	135	11.0	6.0
150	170	12 6	6.0	6.0	2½	165	12.0	10.0	6.0	161	12.0	6.0
175	188	13.0	6 0	6.6	2½	195	14.0	10 0	6 0	190	13.0	6.0
200	230	14 0	6.0	7.0	2½	230	14.0	11.0	6 0	220	14.0	6.0
250	273	15 0	6.6	7.6	2½	275	16.0	11.0	7.0	273	15 0	6 6
300	330	16.0	7.0	8.0	3	315	16.0	12 0	7.0	330	16.0	6 9
350	377	17.0	7.0	8.0	3	380	18.0	12.0	7.0	380	17.0	7 0
400	423	18.0	7.0	8.0	3	425	20 0	12.0	7.6	423	18.0	7.0
450	445	18.6	7.0	8.0	3	480	20.0	13.0	7.6	471	19 0	7 0
500	500	19.6	7.0	8.0	3	520	20.0	14.0	7.6	523	20.0	7.0

WATER-TANKS.

	Round.							Square					
					Copper Coil.						Copper Coil.		
Number of Barrels in Cellar.	Contents in Barrels.	Diameter.	Height.	Diameter of Water Outlet.	Length.	Diam.	Heating Surface in Square Feet.	Contents in Barrels.	Side of Square.	Height.	Length.	Diam.	Heating Surface in Square Feet.
		ft. in.	ft. in.	in.	ft. in.	in.			ft. in.	ft. in.	ft. in.	in.	
25	50	7 6	5 0	2	30 0	2½	25.35	55	7 0	5.0	39.0	2½	35.35
35	70	8 0	6 0	2	55.0	2½	35 75	72	7.6	5 6	58.0	2½	38.4
50	85	8.0	8 0	2½	55.0	2½	35.75	96	8 0	6.6	70.0	2½	48 4
75	120	9.0	8 0	2½	100 0	2½	65.	120	8.0	8.0	105.0	2½	68.
100	165	10.0	9 0	2½	125 0	2½	81.25	161	9.0	8 6	130.0	2½	88.
125	200	11.0	9 0	2½	125.0	2½	81.25	190	9.6	9 0	144.0	2½	93 5
150	240	12.0	9 0	3	125 0	2½	81.25	240	10.6	9.6	100.0	2½	104.
175	280	13.0	9.0	3	140 0	2½	91	249	11 0	9 6	168.0	2½	109.
200	315	13.0	10.0	3	142 0	3	113.6	310	11.6	10.0	176.0	3	140.8
250	380	14 0	10 6	3	142 0	3	113 6	370	12.0	11.0	184.0	3	147.
300	460	15.0	11.0	3	175 0	3	140.	435	13.0	11.6	200.0	3	160.
350	530	15.6	12.0	3	210.0	3	168.	550	14 0	12 0	216.0	3	172.8
400	*620*	*16 0*	13.0	4	210 0	3	168.	625	14.0	13.6	243 0	3	194 4
450	*640*	*16 0*	13 6	4	218.0	3	200.	670	14 6	13 6	280.0	3	224.
500	*660*	*16 0*	14.0	4	288.0	3	228.8	690	14.6	14 0	308.0	3	246.4

STANDARD DIMENSIONS OF BREWERY VESSELS.

GRAINS-TANK.

Number of Barrels in Cellar.	Round.				Square.			
	Diameter.	Height of Shell.	Height of Conical Bottom.	Contents in Cu. Ft.	Length.	Width.	Height of Shell.	Height of Conical Bottom.
	ft. in.	ft. in.	ft. in.		ft. in.	ft. in.	ft. in.	ft. in.
25	4.0	3.0	2.0	44	5.0	2 6	4.0	2.6
35	4.6	3.6	2.3	62	5.6	2.9	4.6	2.9
50	5.0	3.6	2.6	88	6.0	3.0	4.6	3.0
75	6.0	4.6	3.0	132	7.0	3.6	5.0	3.6
100	6.6	5.0	3.3	176	7.6	3.9	5.9	3.9
125	7.0	5.6	3.6	220	8.0	4.0	6.6	4.0
150	7.6	6.0	3.9	264	8.6	4.3	6.9	4.3
175	8.0	6.0	4.0	308	9.0	4.6	7.0	4.6
200	8 6	6.6	4.3	352	9.6	4.9	7.3	4.9
250	9.0	7.0	4.6	440	10.0	5.0	8.0	5.0
300	9.6	7.6	4.9	528	11.0	5.6	8.6	5.6
350	10.0	8.0	5.0	616	11.6	5.9	9.3	5 9
400	10 6	8.6	5.3	704	12.0	6.0	10.0	6.0
450	11.0	9.0	5.6	792	12.6	6.3	10.3	6 3
500	11.6	9.6	5.9	880	13.0	6.6	11.0	6.6

Table for Single Leather, Four-ply Rubber and Four-ply Cotton Belting, Belts not Overloaded.

1 inch wide, 800 feet per minute = 1 Horse Power.

Speed in Ft. Pr. Minute.	Width of Belt in Inches.											
	2	3	4	5	6	8	10	12	14	16	18	20
	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.
400	1	1½	2	2½	3	4	5	6	7	8	9	10
600	1½	2¼	3	3¾	4½	6	7½	9	10½	12	13½	15
800	2¼	3	4	5	6	8	10	12	14	16	18	20
1000	3	3¾	5	6¼	7½	10	12½	15	17½	20	22½	25
1200	3	4½	6	7½	9	12	15	18	21	24	27	30
1500	3¾	5¾	7½	9½	11½	15	18¾	22½	26½	30	33¾	37½
1800	4½	6¾	9	11¼	13½	18	22½	27	31½	36	40½	45
2000	5	7½	10	12½	15	20	25	30	35	40	45	50
2400	6	9	12	15	18	24	30	36	42	48	54	60
2800	7	10½	14	17½	21	28	35	42	49	56	63	70
3000	7½	11¼	15	18¾	22½	30	37½	45	52½	60	67½	75
3500	8¾	13	17½	22	26	35	44	52½	61	70	79	88
4000	10	15	20	25	30	40	50	60	70	80	90	100
4500	11¼	17	22½	28	34	45	57	69	78	90	102	114
5000	12½	19	25	31	37½	50	62½	75	87½	100	112	125

Double leather, six-ply rubber or six-ply cotton belting will transmit 50 to 75 per cent. more power than is shown in this table. (1 inch wide, 550 feet per minute = 1 horse power).

SIZES AND DIMENSIONS OF STANDARD CORLISS ENGINES.

Size of Cylinder: Diameter	Size of Cylinder: Stroke	Revs.	Indicated Horse Power: 80 lbs. Pressure, 1-5 Cut-off	80 lbs. Pressure, 1-4 Cut-off	80 lbs. Pressure, 1-3 Cut-off	90 lbs. Pressure, 1-5 Cut-off	90 lbs. Pressure, 1-4 Cut-off	90 lbs. Pressure, 1-3 Cut-off	100 lbs. Pressure, 1-5 Cut-off	100 lbs. Pressure, 1-4 Cut-off	100 lbs. Pressure, 1-3 Cut-off	Fly Wheel: Diameter	Fly Wheel: Face	Fly Wheel: Weight in Pounds	Crank Shaft: Diameter	Crank Shaft: Length	Crank Shaft: Center Shaft above Found.	Crank Shaft: Center Shaft to back of Cyl'd'r Head		Steam Pipes: Diam. Steam	Steam Pipes: Diam. Exh'st.	Approx. Shipping Weight. Pounds.
Inch	Inch											Ft.	In.		In.	Ft.	In.	Ft.	In.	In.	In.	
10	24	90	30	36	43	34	41	48	39	49	60	8	13	3500	5	6	25	10	11	3	4	10700
10	30	90	37	45	53	42	51	60	48	58	68	8	13	4300	5	6	25	13		3	4	11750
12	30	90	54	65	76	62	74	87	69	83	97	9	15	5700	6	6½	25	13	4	3½	4½	15550
12	36	85	61	73	86	70	84	98	78	94	110	10	17	6300	6	7	23	15	5	3½	4½	16900
14	36	85	83	100	118	95	114	134	107	128	150	10	19	8900	7	7½	25½	15	6	4	5	22300
14	42	82	93	112	132	107	128	140	120	144	168	12	19	8900	7	7½	25½	17	7	4	6	23700
16	36	82	105	126	140	120	144	167	135	162	187	12	21	10300	8	8	27	15	9	4½	6	26610
16	42	78	116	139	163	133	159	188	150	179	210	12	23	11800	8	8	27	17	10	4½	6	29930
18	36	80	129	155	182	148	177	208	166	199	233	12	25	12900	9	9	30	15	11	5	7	30000
18	42	78	147	176	208	168	202	237	180	217	260	14	25	13300	9	9	30	18		5	7	33800
18	48	75	162	194	227	185	222	259	208	249	291	15	25	15300	9	9	30	20	1	5	7	39570
20	42	75	175	210	246	200	240	280	225	270	314	15	29	16000	10	9	30	18	4	6	8	43450
20	48	72	192	230	268	219	263	307	246	296	346	16	29	18700	10	9	30	20	5	6	8	47612
22	42	75	211	254	298	242	290	340	271	326	382	16	31	21000	11	10	32	18	5	6	8	50600
22	48	72	232	278	326	265	318	368	298	358	410	16	31	23100	11	10	32	20	6	6	8	56220
24	48	70	268	322	380	307	368	432	345	414	486	18	33	24400	12	11	32	20	11	7	9	65140
24	60	65	311	374	438	356	427	500	402	481	561	18	37	30500	12	11	32	25	2	7	9	75740
26	48	70	315	378	445	360	432	507	405	486	570	18	37	28000	13	11½	32	21		7	9	77210
26	60	65	366	439	512	418	502	586	470	564	658	18	37	31000	13	11½	32	25	8	7	10	80000
28	48	68	355	426	503	406	487	568	457	548	640	18	37	31000	14	12	34	21	3	8	12	77920
28	54	66	400	477	554	461	546	631	523	616	709	18	37	31000	14	12	34	23	4	8	12	83000
28	60	65	424	509	594	485	582	655	545	654	763	18	37	31000	14	12	34	25	6	8	12	90000
30	48	68	407	480	571	466	550	653	524	629	754	22	46	83000	15	12½	36	21	8	8	12	93000
30	60	62	464	557	650	531	637	743	597	717	837	24	52	38500	15	12½	36	25	11	8	12	104000
30	72	55	494	593	693	565	678	791	635	762	890	24	60	62000	15	13	36	30	2			127000
32	48	65	443	532	622	507	608	710	570	684	800	24	48	84500	16	13	36	21	11			
32	60	63	529	634	739	604	725	846	680	816	952	24	60	48000	16	13	36	26	2			
32	72	55	563	675	787	643	772	902	723	868	1013	24	60	58200	16	14	36	30	5			

MEMORANDA FOR BUILDERS.

Safe Working Loads for Masonry.

BRICKWORK IN WALLS OR PIERS.

	Tons Per Square Foot. Eastern.	Western.
Red brick in lime mortar	7	5
Red brick in hydraulic lime mortar	..	6
Red brick in natural cement mortar, 1 to 3	10	8
Arch or pressed brick in lime mortar	8	6
Arch or pressed brick in natural cement	12	9
Arch or pressed brick in Portland cement	15	12½

Piers exceeding in height six times their least dimensions should be increased 4 inches in size for each additional 6 feet.

STONEWORK.

(Tons per square foot.)

Rubble walls, irregular stones	3
Rubble walls, coursed, soft stone	2½
Rubble walls, coursed, hard stone	5 to 16
Dimension stone, squared in cement:	
Sandstone and limestone	10 to 20
Granite	20 to 40
Dressed stone, with ⅜-inch dressed joints in cement:	
Granite	60
Marble or limestone, best	40
Sandstone	30

Height of columns not to exceed eight times least diameter.

CONCRETE.

Portland cement, 1 to 8	8 to 15
Rosendale cement, 1 to 6	5 to 10
Hydraulic lime, best, 1 to 6	5

HOLLOW TILE.

(Safe loads per square inch of effective bearing parts.)

Hard fire-clay tiles	80 lbs.
Hard ordinary clay tiles	60 lbs.
Porous terra-cotta tiles	40 lbs.

MORTARS.

(In ½-inch joints, 3 months old, tons per square foot.)

Portland cement, 1 to 4	40
Rosendale cement, 1 to 3	13

Lime mortar, best .... 8 to
Best Portland cement, 1 to 2, in ¼-inch joints for bedding iron plates ....

MEASUREMENT OF BRICKWORK.

Brickwork is generally measured by the one thousand bri laid in the wall, and sometimes by the cubic foot. In estima by the one thousand, the contractor figures on what the bri will cost delivered at the site of the building, and adds to the cost of laying in the wall, including the cost of the mor

The general custom in measuring the exterior brick walls buildings is to compute the total number of brick in the wall, then the number of face or outside brick that will be requi The difference will be the number of common brick. The outs brick generally cost more than those used for the interior, h to be culled, and the labor in laying costs more.

In measuring brickwork, it is customary to deduct all openi for doors, windows, archways, etc.; but not for small flues, e of joists, boxes of window frames, sills, or lintels, etc., on acco of the wastage of material in clipping around or filling in s parts of the work, and the increased amount of time required.

There are different methods of computing the number of b in any given quantity of work. Some contractors will comp the total number of cubic feet of brickwork in the building, multiply by the number of brick contained in a cubic foot, allo ing for wastage, etc. This is probably as accurate a method can be followed. The larger number of masons, however, co pute the superficial area of the walls, and multiply by the num of brick in the wall to one square foot of surface; the number, course, depending upon the thickness of the wall.

In the eastern states, the following scale will be a fair avera

4 in. wall, or ½-brick.......... 7½ bricks per superficial f
8-in. wall, or 1 -brick..........15 bricks per superficial f
12 in. wall, or 1½-brick..........22½ bricks per superficial fo
16 in. wall, or 2 brick..........30 bricks per superficial f
20-in. wall, or 2½-brick..........37½ bricks per superficial f
24 in. wall, or 3 -brick..........45 bricks per superficial fo

In the middle and western states, the bricks are larger, and following scale will be more correct for that section of *country:*

4½-in. wall, or ½-brick.......... 7 bricks per superficial fo
9 -in. wall, or 1 -brick..........14 bricks per superficial f

13 -in. wall, or 1½-brick..........21 bricks per superficial foot.
18 -in. wall, or 2 -brick..........28 bricks per superficial foot.
22 -in. wall, or 2½-brick..........35 bricks per superficial foot.
And seven bricks additional for each half-brick added to thickness.

SHINGLES.

The average width of a shingle is four inches: hence, when shingles are laid four inches to the weather, each shingle averages sixteen square inches, and 900 are required for a square of roofing.

If 4½ inches to the weather, 800 will cover a square.
5 inches to the weather, 720 will cover a square.
5½ inches to the weather, 655 will cover a square.
6 inches to the weather, 600 will cover a square.

This is for common gable-roofs. In hip-roofs, where the shingles are cut more or less to fit the roof, add 5 per cent to above figures.

A carpenter will carry up and lay on the roof from fifteen hundred to two thousand shingles per day, or two squares to two squares and a half of plain gable-roofing.

One thousand shingles laid four inches to the weather will require five pounds of shingle nails to fasten them on. Six pounds of fourpenny nails will lay one thousand split pine shingles.

PAINTING.

Painters' work is generally estimated by the yard, and the cost depends upon the number of coats applied, besides the quality of the work, and the material to be painted.

One coat, or priming, will take, for 100 yards of painting, 20 pounds of lead and 4 gallons of oil. Two-coat work, 40 pounds of lead and 4 gallons of oil. Three-coat, the same quantity as two coats; so that a fair estimate for 100 yards of three-coat work would be 100 pounds of lead and 16 gallons of oil.

1 gallon priming color	will cover 50 superficial yards.
1 gallon white zinc	will cover 50 superficial yards.
1 gallon white paint	will cover 44 superficial yards.
1 gallon lead color	will cover 50 superficial yards.
1 gallon black paint	will cover 50 superficial yards.
1 gallon stone color	will cover 44 superficial yards.
1 gallon yellow paint	will cover 44 superficial yards.
1 gallon blue color	will cover 45 superficial yards.
1 gallon green paint	will cover 45 superficial yards.
1 gallon bright emerald green	will cover 25 superficial yards.
1 gallon *bronze green*	will cover 75 superficial yards.

One pound of paint will cover about 4 superficial yards the coat, and about 6 each additional coat. One pound of putty, stopping, every 20 yards. One gallon of tar and 1 pound of p will cover 12 yards superficial the first coat, and 17 yards additional coat.

A square yard of new brick wall requires, for the first coa paint in oil, ¾ of a pound; and for the second, 3 pounds; for the third, 4 pounds.

A day's work on the outside of a building is 100 yards of coat, and 80 yards of either second or third coat. An ordin door, including casings, will, on both sides, make 8 to 10 ya of painting, or about 5 yards to a door without the casings. ordinary window makes about 2½ or 3 yards.

Fifty yards of common graining is a day's work for a grai and one man to rub in. In painting blinds of ordinary size, 1 a fair day's work for one coat, and 9 pounds of lead and 1 ga of oil will paint them.—(See also "Treatment of Surfaces.")

STRENGTH AND WEIGHT OF MANILA ROPE.

Diameter.	Circumference.	Weight per ft.	Breaking Load		Diameter.	Circumference.	Weight per ft.	Breaking L[oad]	
ins.	ins.	lbs.	lbs.	tons	ins.	ins.	lbs.	lbs.	to[ns]
[illegible]	¾	[illegible]	[illegible]	[illegible]	1.92	6	1.19	25,536	[illegible]
[illegible]	1	[illegible]	784	0.39	2.07	6½	1.39	29,120	[illegible]
0.477	1½	[illegible]	1,568	0.78	2.23	7	1.62	32,704	[illegible]
[illegible]	2	[illegible]	2,733	1.36	2.39	7½	1.86	36,288	[illegible]
0.795	2½	[illegible]	4,278	2.14	2.55	8	2.11	39,872	[illegible]
0.955	3	.297	6,115	3.06	2.86	9	2.67	47,040	[illegible]
1.11	3½	.404	8,534	4.27	3.18	10	3.30	54,208	[illegible]
1.27	4	.528	11,558	5.78	3.50	11	3.99	61,376	[illegible]
1.43	4½	.668	14,784	7.39	3.82	12	4.75	68,544	[illegible]
1.59	5	.825	18,368	9.18	4.14	13	5.58	75,712	[illegible]
1.75	5½	.998	21,952	10.97	4.45	14	6.47	82,880	41

WEIGHT OF COPPER PLATES.

(Brown & Sharpe or American Gauge.)

Gauge Number.	Fraction of an Inch. (Approx.)	Weight of Plates Per Sq. Ft. Copper.	Weight of Plates Per Sq. Ft. Brass.	Gauge Number.	Fraction of an Inch. (Approx.)	Weight of Pla[tes] Per Sq. Ft. Copper.	Weight of Pla[tes] Per Sq. Ft. Bra[ss.]
2	1/4	11.671	11.027	9	7/64	5.184	[illegible]
3	15/64	10.393	9.819	11	3/32	4.111	[illegible]
4	13/64	9.255	8.745	12	5/64	3.661	[illegible]
5	3/16	8.242	7.787	14	1/16	2.903	[illegible]
6	11/64	7.339	6.935	17	3/64	2.050	[illegible]
7	9/64	6.536	6.175	20	1/32	1.018	[illegible]
8	1/8	5.821	5.499	22	1/64	[illegible]	[illegible]

WHITE PINE (OR COMMON SOFT PINE) BEAMS (PER INCH OF WIDTH).

Table of safe quiescent loads for horizontal rectangular beams, supported at both ends, loads *uniformly distributed*. For *concentrated* load at center *divide by two*. For *permanent* loads (such as masonry) reduce by 10 per cent.

Depth of Beam.	SPAN IN FEET.											
	6	8	10	12	14	15	16	17	18	20	22	24	25
Ins.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
6	720	540	432	360	308	......	......	......	......	......	......	......	......
7	980	735	588	490	420	392	......	......	......	......	......	......	......
8	1,280	960	768	640	548	512	480	......	......	......	......	......	......
9	1,620	1,215	972	810	694	648	607	572	......	......	......	......	......
10	2,000	1,500	1,200	1,000	857	800	750	705	666	......	......	......	......
12	2,880	2,160	1,728	1,420	1,234	1,152	1,080	1,016	960	864	......	......	......
14	3,920	2,940	2,352	1,960	1,680	1,568	1,470	1,383	1,308	1,176	1,069	980	940
15	4,500	3,375	2,700	2,250	1,928	1,800	1,687	1,588	1,500	1,350	1,227	1,125	1,080
16	5,120	3,840	3,072	2,560	2,192	2,048	1,920	1,807	1,706	1,536	1,396	1,280	1,230

Loads above and to the right of heavy line will crack plastered ceilings.

WEIGHT OF LUMBER PER THOUSAND (M) FEET.

(Board Measure.)

	Dry.	Partly Seasoned.	Green.
Pine and hemlock	2,500 pounds.	2,700 pounds.	3,000 pounds
Norway and yellow pine	3,000 pounds.	4,000 pounds.	5,000 pounds
Oak and walnut	4,000 pounds.	5,000 pounds.	....
Ash and maple.	3,500 pounds	4,000 pounds.	....

WEIGHTS OF CORDWOOD.

	Pounds	Carbon		Pounds	Carbon
1 cord hickory	4,468	100	1 cord Canada pine ..	1,870	42
1 cord hard maple ...	2,864	58	1 cord yellow oak ...	2,920	61
1 cord beech . ..	3,234	64	1 cord white oak . ..	1,870	81
1 cord ash	3,449	79	1 cord Lombardy poplar	1,775	41
1 cord birch	2,368	49	1 cord red oak .	3,255	70
1 cord pitch pine ...	1,903	43			

RELATIVE HARDNESS OF WOODS.

Taking shell-bark hickory as the highest standard of our forest trees, and calling that 100, other trees will compare with it for hardness as follows:

Shell-bark hickory..........	100	Yellow oak...............	60
Pignut hickory............	90	Hard maple...............	56
White oak...............	84	White elm................	58
White ash...............	77	Red cedar................	56
Dogwood	75	Wild cherry..............	55
Scrub oak...............	73	Yellow pine..............	54
White hazel.............	72	Chestnut	52
Apple-tree	70	Yellow poplar............	51
Red oak.................	69	Butternut	43
White beech.............	65	White birch..............	43
Black walnut............	65	White pine...............	30
Black birch.............	62		

QUANTITY OF NAILS FOR DIFFERENT KINDS OF WORK.

[illegible]	5	pounds 4d. nails, or
	3½	pounds 3d nails
[illegible]	[illegible]	pounds 3d fine
[illegible]	18	pounds 6d box
[illegible]	2[illegible]	pounds 8d common
[illegible]	25	pounds 10d common
[illegible]	38	pounds 10d. floor
[illegible]	41	pounds 12d. floor
[illegible]	5[illegible]	pounds 10d. floor
[illegible]	42	pounds 12d. floor
[illegible]	1	pound 10d common
[illegible]	[illegible]	pounds 10d common
[illegible]	[illegible]	pounds 10d. common
[illegible]	[illegible]	pounds 8d. finish

WROUGHT IRON WELDED STEAM, GAS AND WATER PIPE.—TABLE OF STANDARD DIMENSIONS.

Diameter.			Thickness.	Circumference.		Transverse Areas.			Length of Pipe per Square Foot of		Length of Pipe containing One Cubic Foot.	Weight per Foot of Length.	No of Thr'ads per Inch of Screw.	Contents in Gals. per Foot of Length	Weight of Water per Foot of Length
Nominal Internal.	Actual External.	Actual Internal.		External.	Internal.	External.	Internal.	Metal.	External Surface.	Internal Surface.					
Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Sq. Inch.	Sq. Inch.	Sq. Inch.	Feet.	Feet.	Feet.	Lbs.		Gallons.	Lbs.
1/8	.405	.27	.068	1.272	.848	.129	.0573	.0717	9.44	14.15	2513.	.241	27	.0006	.005
1/4	.54	.364	.088	1.696	1.144	.229	.1041	.1249	7.075	10.49	1383.3	.42	18	.0026	.021
3/8	.675	.494	.091	2.121	1.552	.358	.1917	.1663	5.657	7.73	751.2	.559	18	.0057	.047
1/2	.84	.623	.109	2.639	1.957	.554	.3048	.2492	4.547	6.13	472.4	.837	14	.0102	.085
3/4	1.05	.824	.113	3.299	2.589	.866	.5333	.3327	3.637	4.635	270.	1.115	14	.0230	.190
1	1.315	1.048	.134	4.131	3.292	1.358	.8626	.4954	2.904	3.645	166.9	1.668	11½	.0408	.349
1¼	1.66	1.38	.14	5.215	4.335	2.164	1.496	.668	2.301	2.768	96.25	2.244	11½	.0638	.527
1½	1.9	1.611	.145	5.969	5.061	2.835	2.038	.797	2.01	2.371	70.66	2.678	11½	.0918	.760
2	2.375	2.067	.154	7.461	6.494	4.43	3.356	1.074	1.608	1.848	42.91	3.609	11½	.1632	1.356
2½	2.875	2.468	.204	9.032	7.753	6.492	4.784	1.708	1.328	1.547	30.1	5.739	8	.2550	2.116
3	3.5	3.067	.217	10.996	9.636	9.621	7.388	2.243	1.091	1.245	19.5	7.536	8	.3673	3.049
3½	4.	3.548	.226	12.566	11.146	12.566	9.887	2.679	.955	1.077	14.57	9.001	8	.4998	4.155
4	4.5	4.026	.237	14.137	12.648	15.904	12.73	3.174	.849	.949	11.31	10.665	8	.6528	5.405
4½	5.	4.508	.246	15.708	14.162	19.635	15.961	3.674	.764	.848	9.02	12.34	8	.8263	6.851
5	5.563	5.045	.259	17.477	15.849	24.306	19.99	4.316	.687	.757	7.2	14.502	8	1.020	8.500
6	6.625	6.065	.28	20.813	19.054	34.472	28.888	5.584	.577	.63	4.98	18.762	8	1.469	12.312
7	7.625	7.023	.301	23.955	22.063	45.664	38.738	6.926	.501	.544	3.72	23.271	8	1.999	16.662
8	8.625	7.982	.322	27.096	25.076	58.426	50.04	8.386	.443	.478	2.88	28.177	8	2.611	21.750
9	9.625	8.937	.344	30.238	28.076	72.76	62.73	10.03	.397	.427	2.29	33.701	8	3.300	27.500
10	10.75	10.019	.366	33.772	31.477	90.763	78.839	11.924	.355	.382	1.82	40.065	8	4.081	34.000
11	12.	11.25	.375	37.699	35.343	113.098	99.402	13.696	.318	.339	1.456	45.95	8	......	......
12	12.75	12.	.375	40.055	37.7	127.677	113.098	14.579	.299	.319	1.27	48.985	8	......	......
13	14.	13.25	.375	43.982	41.626	153.938	137.88	16.051	.273	.288	1.04	53.922	8	......	......
14	15.	14.25	.375	47.124	44.768	176.715	159.485	17.23	.255	.268	.903	57.893	8	......	......
15	16.	15.25	.375	50.265	47.909	201.062	182.655	18.407	.239	.250	.788	61.77	8	......	......
....	18.	17.25	.375	56.549	54.192	254.47	233.706	20.764	.212	.221	.616	69.66	....	......	......
....	20.	19.25	.375	62.832	60.476	314.16	291.04	23.12	.191	.198	.495	77.57	....	......	......
....	22.	21.25	.375	69.115	66.759	380.134	354.657	25.477	.174	.179	.406	85.47	....	......	......
....	24.	23.25	.375	75.398	73.042	452.39	424.558	27.832	.159	.164	.339	93.37	....	......	......

WROUGHT IRON WELDED EXTRA STRONG PIPE. TABLE OF STANDARD DIMENSIONS.

Nominal Internal Diameter	Actual External Diameter	Actual Internal Diameter	Thickness	Nearest Wire Gauge	Circumference External	Circumference Internal	Transverse Areas External	Transverse Areas Internal	Transverse Areas Metal	Length of Pipe per Square Foot of External Surface	Length of Pipe per Square Foot of Internal Surface	Nominal Weight per Foot
Inches	Inches	Inches	Inches	No.	Inches	Inches	Sq. Inches	Sq. Inches	Sq. Inches	Feet	Feet	Pounds
⅛	.405	.205	.1	12½	1.272	.644	.129	.033	.096	9.433	18.632	.29
¼	.54	.294	.123	11	1.696	.924	.229	.068	.161	7.075	12.986	.54
⅜	.675	.421	.127	10½	2.121	1.323	.358	.139	.219	5.657	9.07	.74
½	.84	.542	.149	9	2.639	1.703	.554	.231	.323	4.547	7.046	1.09
¾	1.05	.736	.157	8½	3.299	2.312	.866	.452	.414	3.637	5.109	1.39
1	1.315	.951	.182	7	4.131	2.988	1.358	.71	.648	2.904	4.016	2.17
1¼	1.66	1.272	.194	6½	5.215	3.996	2.164	1.271	.893	2.301	3.003	3
1½	1.9	1.494	.203	6	5.969	4.694	2.835	1.753	1.082	2.01	2.556	3.63
2	2.375	1.933	.221	5	7.461	6.073	4.43	2.935	1.495	1.608	1.975	5.02
2½	2.875	2.315	.28	2	9.032	7.273	6.492	4.209	2.283	1.328	1.649	7.67
3	3.5	2.892	.304	1	10.996	9.085	9.621	6.569	3.052	1.091	1.328	10.25
3½	4.	3.358	.321	0	12.566	10.549	12.566	8.856	3.71	.955	1.137	12.47
4	4.5	3.818	.341	0	14.137	11.995	15.904	11.449	4.455	.849	1	14.97
5	5.563	4.813	.375	00	17.477	15.120	24.306	18.193	6.12	.687	.793	20.54
6	6.625	5.75	.437	000	20.813	18.064	34.472	25.967	8.505	.577	.664	28.58

DOUBLE EXTRA STRONG PIPE.

½	.84	.244	.298	1	2.639	.766	.554	.047	.507	4.547	15.667	1.7
¾	1.05	.422	.314	1	3.299	1.326	.866	.139	.727	3.637	9.049	2.44
1	1.315	.587	.364	00	4.131	1.844	1.358	.271	1.087	2.904	6.508	3.65
1¼	1.66	.885	.388	00	5.215	2.78	2.164	.615	1.549	2.301	4.317	5.2
1½	1.9	1.088	.406	000	5.969	3.418	2.835	.93	1.905	2.01	3.511	6.4
2	2.375	1.491	.442	0000	7.461	4.684	4.43	1.744	2.686	1.608	2.561	9.02
2½	2.875	1.755	.560	$\frac{5}{16}$	9.032	5.513	6.492	2.419	4.073	1.328	2.176	13.68
3	3.5	2.284	.608	⅜—	10.996	7.175	9.621	4.097	5.524	1.091	1.672	18.56
3½	4.	2.716	.642	⅝+	12.566	8.533	12.566	5.794	6.772	.955	1.406	22.75
4	4.5	3.136	.682	$\frac{11}{16}$	14.137	9.852	15.904	7.724	8.18	.849	1.217	27.48
5	5.563	4.063	.75	¾	17.477	12.764	24.306	12.965	11.34	.687	.940	38.12
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	15.315	34.472	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

SEAMLESS DRAWN BRASS AND COPPER TUBES.

(Pounds per Lineal Foot.)

The upper figures denote copper, the lower brass, tubes.

Thickness, Decimal of an Inch.	Fraction of an Inch (Closely).	Gauge Number.	Outside Diameters in Inches. Brown & Sharpe or American Gauge.									
			½	¾	1	1¼	1½	2	2½	3	4	5
0.081	5-64	12	0.41 0.39	0.65 0.62	0.90 0.86	1.14 1.09	1.39 1.32	1.88 1.79	2.37 2.26	2.86 2.72	3.84 3.66	4.82 4.59
0.064	1-16	14	0.34 0.32	0.54 0.51	0.69 0.65	0.88 0.83	1.06 1.00	1.43 1.34	1.80 1.69	2.28 2.17	3.06 2.91	3.83 3.65
0.051	....	16	0.27 0.26	0.43 0.41	0.59 0.56	0.73 0.70	0.89 0.85	1.20 1.14	1.51 1.44	1.82 1.73	2.44 2.32	3.04 2.90
0.045	3-61	17	0.25 0.24	0.39 0.37	0.52 0.50	0.66 0.63	0.80 0.76	1.07 1.02	1.34 1.28	1.62 1.54	2.16 2.06	2.72 2.59
0.040	....	18	0.22 0.21	0.35 0.33	0.47 0.45	0.59 0.56	0.71 0.68	0.96 0.91	1.20 1.14	1.45 1.38	1.93 1.84	2.43 2.31
0.036	....	19	0.20 0.19	0.31 0.30	0.42 0.40	0.52 0.50	0.64 0.61	0.85 0.81	1.07 1.02	1.29 1.23	1.72 1.64	2.15 2.05
0.032	1-32	20	0.18 0.17	0.27 0.26	0.38 0.32	0.47 0.45	0.57 0.54	0.77 0.73	0.96 0.91	1.14 1.09	1.53 1.46	1.92 1.83
0.285	....	21	0.16 0.155	0.25 0.24	0.34 0.32	0.42 0.40	0.50 0.48	0.68 0.65	0.85 0.81	1.02 0.97	1.36 1.30	....
0.053	....	22	0.146 0.139	0.226 0.211	0.30 0.285	0.37 0.358	0.45 0.43	0.61 0.58	0.77 0.73	0.91 0.87	1.22 1.16	....

HORSEPOWER OF BOILERS.

Thirty pounds of water evaporated at 70 pounds steam pressure per hour from feed water at 100° = 1 horsepower. In calculating horsepower of steam boilers, consider for:

Tubular boilers 15 square feet of heating surface equivalent to one horsepower.

Flue boilers 12 square feet of heating surface = 1 horsepower.

Cylinder boilers 10 square feet of heating surface = 1 horsepower.

HORSEPOWER OF BELTING.

A simple rule of ascertaining transmitting power of belting, without first computing speed per minute that it travels, is as follows: Multiply diameter of pulley in inches by its number of revolutions per minute, and this product by width of the belt in inches; *divide this product by* 3,300 for single belting, or by 2,100 *for double* belting, and the quotient will be the amount of horsepower *that* can be safely transmitted.

TEMPERATURE OF FIRE.

By reference to the table of fuels (p. 777), it will be seen t the temperature of the fire is nearly the same for all kinds combustibles under similar conditions. If the temperature known, the conditions of combustion may be inferred. The f lowing table, from M. Pouillet, will enable the temperature to judged by the appearance of the fire:

Appearance.	Temperature F.	Appearance.	Temper ture F
Red, just visible	977°	Orange, deep	2010°
Red, dull	1290°	Orange, clear	2190°
Red, cherry, dull	1470°	White heat	2370°
Red, cherry, full	1650°	White, bright	2550°
Red, cherry, clear	1830°	White, dazzling	2730°

To determine temperature by fusion of metals, etc.:

Substance.	Temperature F.	Metal.	Temperature F.	Metal.	Tempe ture F
Tallow	92°	Bismuth	518°	Silver, pure	1830°
Spermaceti	1[illegible]0°	Lead	630°	Gold coin	2156°
Wax, white	151°	Zinc	793°	Iron, cast, med.	2010°
Sulphur	239°	Antimony	810°	Steel	2550°
Tin	455°	Brass	1650°	Wrought-iron	2910°

IRON PIPE SIZE BRASS TUBES.

Made to correspond with Iron Tubes, and to fit Iron Tul Fittings.

List of Sizes, Lengths, Etc.

Outside Diameter.	Same as Iron Size.	Weight Per Foot.	
		Brass.	Copper.
13-32 inch	1 8 inch.	.30 pounds.	.31 pounds
9-16 "	1 4 "	.43 "	.45 "
11-16 "	3 8 "	.58 "	.61 "
13 16 "	1 2 "	.80 "	.81 "
1 1 16 "	3-4 "	1 17 "	1.23 "
1 5-16 "	1 "	1.67 "	1.75 "
1 5-8 "	1 1-4 "	2 42 "	2.54 "
1 7 8 "	1 1 2 "	2.92 "	3.07 "
2 3 8 "	2 "	4 17 "	4.38 "
2 7 8 "	2 1-2 "	5. "	5.25 "
3 1 2 "	3 "	8 "	8.40 "
4 "	3 1 2 "	10. "	10.50 "
4 1-2 "	4 "	12. "	12.60 "

MEASUREMENTS AND WEIGHTS OF MERCHANDISE AS USUALLY STORED IN WAREHOUSES.

MATERIAL.	MEASUREMENTS.		WEIGHTS.		
	Floor space.	Cubic feet.	Gross.	Per square ft.	Per cubic ft.
COTTON, ETC.					
Bale	8.1	44.2	515	64	12
Bale, compressed	4.1	21.6	550	134	25
Bale, jute	2.4	9.9	300	125	30
COTTON GOODS.					
Jute bagging	1.4	5.3	100	70	24
GRAIN.					
Wheat in bags	4.2	4.2	165	39	39
Wheat in bulk	....	....	....	....	44
Wheat in bulk	....	....	....	....	39
Wheat in bulk, mean	....	....	....	....	41
Barrels flour on side	4.1	5.4	218	53	40
Barrels flour on end	3.1	7.1	218	70	31
Corn in bags	3.6	3.6	112	31	31
Cornmeal in barrels	3.7	5.9	218	59	37
Oats in bags	3.3	3 6	96	29	27
Bale of hay	5.0	20.0	284	57	14
Hay, Dederick compressed	1.75	5.25	125	72	24
Straw, Dederick compressed	1.75	5.25	100	57	19
Tow, Dederick compressed	1.75	5.25	150	86	29
Excelsior, Dederick compr'd	1.75	5.25	100	57	19
DYE STUFFS, ETC.					
Hogshead bleaching powder	11.8	39.2	1200	102	31
Hogshead soda ash	10.8	29.2	1800	167	62
Barrel starch	3.0	19.5	250	83	23
Barrel lime	3.6	4.5	225	63	50
Barrel cement, American	3.8	5.5	325	86	59
Barrel plaster	3.7	6.1	325	88	53
Barrel rosin	3.0	9.0	430	143	48
Rope	....	....	....	....	42
MISCELLANEOUS.					
Bale leather	7.3	12.9	190	26	16
Barrel granulated sugar	3.0	7.5	317	106	42

TABLE GIVING THE PRESSURE IN POUNDS DUE TO ANY CERTAIN HEIGHT OF A COLUMN OF WATER.

Head in Feet.	Pressure in Pounds Per Square In.	Head in Feet.	Pressure in Pounds Per Square In.	Head in Feet.	Pressure in Pounds Per Square In.	Head in Feet.	Pressure in Pounds Per Square In.
1	0.43	20	8.66	55	23.83	90	38.90
2	0.88	25	10.83	60	25.90	95	41.07
3	1.30	30	12.	65	28.06	100	43.33
4	1.74	35	15 16	70	30.55	125	54.17
5	2.16	40	17.33	75	32 72	150	65.
10	4.33	45	19.50	80	34.66	175	76.05
15	6 50	50	21.66	85	36.83	200	86.67

1 lb. pressure per square inch is equivalent to a head of water of 2.3093 feet, or 27.71 inches.

14.7 lbs. pressure per square inch, or 1 atmosphere, is equivalent to a head of water of 33.947 feet.

14.7 lbs. pressure per square inch, or 1 atmosphere, is equivalent to a head of water of 33.947 feet, or 10.347 meters.

COMPARATIVE TABLE OF BEAUME DEGREES AND SPECIFIC GRAVITY ACCORDING TO BOURGOUGNON.

FOR LIQUIDS HEAVIER THAN WATER.

Deg. B.	Sp. Gr.	Deg. B.	Sp. Gr.	Deg. B.	Sp. Gr.	Deg. B.	Sp. Gr.
0	1.0000	19	1.1516	38	1.3574	57	1.6527
1	1.0069	20	1.1608	39	1.3703	58	1.6719
2	1.0140	21	1.1702	40	1.3834	59	1.6915
3	1.0212	22	1.1798	41	1.3968	60	1.7115
4	1.0285	23	1.1896	42	1.4104	61	1.7321
5	1.0358	24	1.1994	43	1.4244	62	1.7531
6	1.0433	25	1.2095	44	1.4386	63	1.7748
7	1.0509	26	1.2197	45	1.4530	64	1.7968
8	1.0586	27	1.2301	46	1.4678	65	1.8194
9	1.0665	28	1.2407	47	1.4829	66	1.8427
10	1.0744	29	1.2514	48	1.4983	67	1.8665
11	1.0825	30	1.2624	49	1.5140	68	1.8909
12	1.0906	31	1.2736	50	1.5301	69	1.9161
13	1.0989	32	1.2849	51	1.5465	70	1.9418
14	1.1074	33	1.2964	52	1.5632	71	1.9683
15	1.1159	34	1.3081	53	1.5802	72	1.9955
16	1.1246	35	1.3201	54	1.5978	73	2.0235
17	1.1335	36	1.3323	55	1.6157	74	2.0523
18	1.1424	37	1.3447	56	1.6340	75	2.0819

FOR LIQUIDS LIGHTER THAN WATER.

Deg. B.	Sp. Gr.	Deg. B.	Sp. Gr.	Deg. B.	Sp. Gr.	Deg. B.	Sp. Gr.
10	1.000	23	0.918	36	0.849	49	0.789
11	0.993	24	0.913	37	0.844	50	0.785
12	0.986	25	0.907	38	0.839	51	0.781
13	0.980	26	0.901	39	0.834	52	0.777
14	0.973	27	0.896	40	0.830	53	0.773
15	0.967	28	0.890	41	0.825	54	0.768
16	0.960	29	0.885	42	0.820	55	0.764
17	0.954	30	0.880	43	0.816	56	0.760
18	0.948	31	0.874	44	0.811	57	0.757
19	0.942	32	0.869	45	0.807	58	0.753
20	0.936	33	0.864	46	0.802	59	0.749
21	0.930	34	0.859	47	0.798	60	0.745
22	0.924	35	0.854	48	0.794		

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Abbreviations:

A. B. R.,	American Brewers' Review
Am. Br.,	American Brewer.
Am. Ch. R.,	American Chemical Review
Br. J.,	Brewers' Journal.
Br. & M.,	Brewer and Maltster.
Brm.,	Der Braumeister.
Ice & R.,	Ice and Refrigeration.
Pr. Bb.,	Der praktische Bierbrauer
W. Br.,	Western Brewer.

Roman numerals indicate volume.
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DICTIONARY OF TECHNICAL TERMS.

English-German.

In the following pages an attempt has been made to collect the technical terms commonly used by brewers and maltsters, together with their German equivalents.

Completeness is not claimed for this little dictionary, but the publishers have endeavored to make it as complete as a first attempt in this line allowed.

Abbreviations:

Bot.,	Botany.	Lab.,	Laboratory.
Mic.,	Microscopy.	Top-F.,	Top-Fermentation.
Mech.,	Mechanics.		

A.

Accelerated fermentation, Schnellgärung.
Acetic acid, Essigsäure.
Acidity, Säuregehalt.
Acrospire (bot.), Blattkeim.
Adjunct, Surrogat.
Adjustable, verstellbar.
Adjustment (mic.), Einstellung.
Aerate, lüften.
After-fermentation, Nachgärung.
Age (beer), Reife.
Aging, ablagern.
Agitate (yeast), aufziehen.
Air drying (malt), Schwelke.
— **examination**, Luftuntersuchung.
— **chamber**, Luftbehälter.
Albuminoid turbidity, Eiweißtrübung.
Albuminoids, Eiweißkörper.
Aliment, Nahrung.
Alloy, Legierung.
Alum, Alaun.
Amber malt, Farbmalz.
Ammonia, Ammoniak.
Amylic alcohol, Fuselöl, Amylalkohol.
Analytical, auflösend, zerlegend, analytisch.
Anhydrous ammonia, wasserfreies Ammoniak.
Angle, Winkel.
Animal charcoal, Knochenkohle.
Anneal, einbrennen.
Aperture (mic.), Oeffnung.
Apparent attenuation, scheinbare Attenuation.
— **degree of attenuation**, scheinbarer Vergärungsgrad.
— **extract**, scheinbarer Extrakt.
Arc light, Bogenlicht.
Arch, Gewölbe.
Areometer, Senkwage.
Arrested fermentation, Rastgärung.
Artificial ice, Kunsteis.
Ascus (bot.), Sack.
Ash-pit (mech.), Aschenfall.
Aspergillus, Kolbenschimmel.
Assimilate, assimiliren, einverleiben.
Atmospheric cooler, Berieselungskühler.
— **condenser**, Berieselungskondensator.
Atomizer, Verstäubungsapparat.
Attemperator, Schwimmer.
Attenuation, Vergärung.
Attraction, Anziehungskraft.
Auto-fermentation, Selbstgärung.
Automatic masher, Vormaischer.

B.

abbit metal, Zapfenlagermetall; Büchsenmetall.
acillus, Stabbakterie.
ack, Bütte.
ackpressure, Gegendruck.
acteria, Bakterien; Spaltpilze.
alance, Wage.
all, Kugel.
— and socket joint (mech.), Kugelgelenk.
alling of beer, scheinbarer Extrakt.
— of wort, Saccharometeranzeige der Würze, Stammwürze.
are spots (fermentation), kahle Platten.
arley, Gerste.
arm, Hefe.
asswood, Lindenholz.
ead, Schaum.
eaker (lab.), Becher.
eam, Träger.
— scale, Hebelwage.
earing (mech.), Zapfenlager.
eech (bot), Buche.
eet sugar, Rübenzucker.
elt (mech.), Riemen.
— conveyor, Gurtentransporteur.
enzoic acid, Benzoësäure.
evel wheel, Kegelrad; Winkelrad.
ibb, Wasserkrahn.
icarbonate of soda, doppelt kohlensaures Natron.
isulphide of carbon, Schwefelkohlenstoff.
isulphite of lime, doppelt schwefligsaurer Kalk.
— of potash, doppelt schwefligsaures Kali.
— of soda, doppelt schwefligsaures Natron.
iting test (steeped barley), Bißprobe.
lack malt, Röstmalz.
— beers (top f.), dunkle Biere, schwarze Biere.
— mold (barley), schwarzer Schimmel; Cladosporium herbarium.
lackened tips (barley), schwarze Spitzen.
last, Gebläse.
lastomycetes, Hefenpilze.
leaching (barley), bleichen, schwefeln.
— powder, Chlorkalk.
lend (beers), verschneiden; verstechen.
light, Mehlthau.
lock and tackle (mech.), Flaschenzug.
low-off cock, Probierhahn.

Blue vitriol, Kupfervitriol, Kupfersulfat.
Body (beer), Vollmundigkeit.
Boil, to, sieden.
Boiler, Dampfkessel.
— compound, Kesselsteinmittel.
— scale, Kesselstein.
Boiling down (wort), Einkochen.
Boiling fermentation, kochende Gärung.
— point, Siedepunkt.
Bolt (mech.), Bolzen.
— to, beuteln, sieben.
Bone-black, Knochenkohle.
Boracic acid, Borsäure.
Bottle beer, Flaschenbier.
Bottling department, Flaschenbierabtheilung.
— fitness (top f.), flaschenreif.
Bottom fermentation, Untergärung.
Box malting (pneumatic), Kastenmälzerei.
Bracts (hops), Deckblätter.
Branching, verzweigen.
Branding, brandmarken.
— iron, Brenneisen.
Brass, Messing.
Break (wort), Bruch.
Brew, Gebräu; Sud.
Brewer's grains, Treber.
Brewhouse, Sudhaus.
Brilliancy, Glanz.
Brilliant, glanzfein.
Brine, Salzlösung.
Brittle, spröde.
Brush, Bürste; Pinsel.
Brush mold, Pinselschimmel; Penicillium glaucum.
Brewers pounds (top f.), Grade nach Long's Saccharometer.
Bubble fermentation, blasige Gärung.
Bucket elevator, Becher (Hebe) Werk.
Budding, sprossen.
— fungi, Hefepilze.
Bulb, Kugel.
Bung, Spund; Spundzapfen.
— to, spunden; zuschlagen.
— plug, Spundzapfen.
— stave, Spunddaube.
Bunging apparatus, Spundapparat.
Buoyant malt, diastasereiches Malz.
Burette (lab.), Meßrohr.
Burr, Hopfenblüthe.
Burtonising (water), Härten von weichen Wässern.
Bushing, Spundring.
Butyric acid, Buttersäure.
By-products, Nebenprodukte.

C.

alcic bisulphite, doppelt schwefligsaurer Kalk.
alory, Wärmeeinheit; Calorie.
am (mech.), Hebebaumen.

Cane sugar, Rohrzucker.
Capillary attraction, Haarröhrenanziehungskraft; Capillarität.
Captive yeast, gefesselte Hefe.

Carbohydrates (chem.), Kohlehydrate.
Carbon, Kohlenstoff.
— dioxide, Kohlensäure.
— monoxide, Kohlenoxyd.
Carbonate, to, karbonisiren.
— of ammonia, Hirschhornsalz.
— — lime, kohlensaurer Kalk.
— — soda, kohlensaures Natron.
— — potash, kohlensaures Kali.
Carbonic acid, Kohlensäure.
Carriage cask (top f.), Fuhrfaß.
Cask, Faß.
Cast iron, Gußeisen.
Castings, Gußwaaren.
Catalysis, Contaktwirkung.
Catch-basin, Senkgrube.
Catkin (hops), Dolde.
Caulk, kalfatern.
Caustic potash, Aetzkali.
— soda, Aetznatron.
Cedar, red, amerikanische Ceder.
Cement, Cement; Kitt.
Cell, Zelle.
— juice, Zellsaft.
Cellar taste, Kellergeschmack.
Cellarage, Kellerei.
Cellulose, Pflanzenfaser.
Cereals, Getreidearten.
Cesspool, Senkgrube.
Chaff, Spreu; Häcksel, Spelze.
Change steep water, auffrischen.
— of yeast, Hefewechsel.
Characteristics, Kennzeichen; Merkmale.
Charcoal, Holzkohle.
Charge (with carbonic acid), imprägniren, carbonisiren.
Check, Biermarke.
— valve (mech.), Rückschlagsventil.
Chestnut, Kastanie.
Chill, abschrecken.
Chimney, Schornstein.
Chipcask, Spanfaß.
Chipping, Späne stecken.
Chips, Späne.
Chit (malt), spitzen.
Chloride of calcium, Chlorcalcium.
— — lime, Chlorkalk.
— — sodium, Chlornatrium; Kochsalz.
Chlorophyll, Pflanzengrün.
Chromogenic (bot.), farbenerzeugend.
Circle, Kreis.
Circulate (wort), verschieben.
Circulator pump, Vorlauf-, Maischepumpe.
Circumference, Umfang.
Clarification, Klärung.
Clarify (of waters), klären.
Clarifying chips, Klärspäne.
Clasp, Klammer.
Clay, Thon.
Clayey (appearance of wort), lehmig.
Cleansing (top f.), ausschaffen; ausstoßen.
— agents, Reinigungsmittel.
— cask, Gärfaß.
Cleansing system (top f.), Ausstoß-(Burton), Faßgärungs-System.
Clearance (mech.), schädlicher Raum.
Clearing (kiln), abräumen.
Cloudiness, Trübung.
Closure, Verschluß.
Club mold, Kolbenschimmel.
Coagulate, gerinnen.
Coccus, Kugelbakterie.
Cock, Hahn.
Cogwheel (mech.), Zahnrad; Kammrad.
Colander, Sieb.
Cold break (of wort), kalter Bruch.
— water extract of malt, kalter Satz.
Collar, shaft, (mech.), Stellring.
Collecting vat, vessel, Sammelbottich.
Color producing bacteria, Pigmentbakterien.
Combustion, Verbrennung.
Come through, ankommen. (Kräusen.)
Complementary fermentation, Nachgärung.
Composite yeast, Mischhefe.
Composition, Zusammensetzung.
Compound machines, Mehrcylindermaschinen.
Compressed yeast, Preßhefe.
Concave mirror, Hohlspiegel.
Concentrating, eindampfen.
Concrete, Beton; Steinmörtel.
Concussion, Stoß.
Condenser, Kondensator.
Condition (beer), Trieb; Marktreife, Beschaffenheit.
— (hops), Lupulingehalt.
Conductor (heat), Wärmeleiter.
Cone, Kegel.
Cone (hops), Dolde.
Connecting rod, Pleuelstange.
Constituent, Bestandtheil.
Constricted, eingeschnürt.
Contamination, Verunreinigung.
Contraction, Zusammenziehung.
Control of brewing operations, Betriebskontrolle.
Convert, to (starch), aufschließen.
Converter, Dämpfer.
Conveyor, Transportschnecke; Schraubentransporteur.
Cool, abkühlen.
Cooler deposit, Trub.
Coombs, trockene Wurzelkeime.
Cooper, Küfer.
Cooperage, Küferwerkstatt, Gebinde.
Copper, Kessel.
Corking, verkorken.
Corrosion, Zerfressung.
Corrugated, gerippt.
Cotton filter, Baumwollenfilter.
— seed oil, Baumwollsamenöl.
Couch, Haufen; Tenne.
— to, nachweichen.
Counter-balance, Gegengewicht.
— current cooler (mech.), Gegenstromkühler.

Counter pressure, Gegen-druck, isobarometrischer.
— shaft (mech.), Gegenwelle.
Coupling, Kuppel.
Cover (fermenting beer), Decke.
— glass (mic.), Deckglas.
Crane, Krahn; Laufkrahn.
Crank (mech.), Kurbel.
— pin, Kurbelzapfen.
Crisp (malt), mürbe.
Crop, outcrop (yeast), Hefeernte.
Cross head, Kreuzkopf.
Crusher, Malzmühle.
Crushing (malt), brechen.
Culture medium, Nährboden.
— yeast, Kulturhefe.
Cured malt, Darrmalz.
Curing, darren.
— temperature (kilning), Abdarrtemperatur.
Current, Strom.
Cut-off (mech.), Füllungsgrad.
Cutting (of plant), Ableger.
— (isinglass), aufquellen durch Säuren

D.

Damper, Klappe.
Dead center (mech.), todter Punkt.
— mash, schlecht abläuternde Maische.
Decoction mash, Dickmaische.
Degerminate (corn), entkeimen.
Degree of attenuation, Vergärungsgrad.
Degenerate (yeast), ausarten.
Density of wort, Stammwürze.
— of beer, scheinbarer Extrakt.
Deposit, Niederschlag; Absatz; Bodensatz.
Derrick, Krahn.
Deteriorate, an Werth verlieren.
Diameter, Durchmesser.
Diaphragm (mic.), Blende.
Diastatic power, diastatische Kraft.
Digester, Autoclave.
Dilution method (cultures), Verdünnungsmethode.
Disc, Scheibe.
Discontinuous sterilisation, abgebrochene Sterilisirungsmethode.
Dissolve, auflösen.
Dormant, unthätig.
Double acting (mech.), doppeltwirkend.
— row barley, zweizeilige Gerste.
Doubling (ferm.), Daraufläffen.
Doughing in, einmaischen, einteigen.
Draft, Luftzug.
Drainage, Kanalisation.
Draught beer, Schankbier.
Drawings, Restbiere.
Drawing off (wort), abläutern.
Dregs, Trub.
Dressing, Gärungsbeschleunigung durch Malzmehl.
Dried grains, Trockentreber.
Drop hanger, Hängelager.
Droplet culture (mic.), Tröpfchenkultur.
Drum (germinating), Keim-Apparat; -Trommel.
Dry (on kiln), darren.
— addition (yeast), Trockengeben.
Dry hopping, Hopfen geben im Keller; Hopfen stopfen.
— residue, Trockensubstanz.
— rot, trockene Fäulniß.
Drying floor, Schwelke, Schwelchboden.
— off (malt), abdarren.
Dumping grate, Kipprost.
— kiln floor, Kipphorbendarre.
Duplex (mech.), doppeltwirkend; zweigliedrig.
Durability, Haltbarkeit.
Duration of boiling, Kochdauer.
Dust collector, Staubsammler.

E.

Ear (grain), Aehre.
Ebullition, Sieden.
Economizer (water), Vorwärmer.
Effervescence, Mousseux; Aufbrausen.
Efficiency (mech.), Leistungsfähigkeit.
Elevator (grain), Speicher.
— Becherwerk.
Elm, Ulme.
Embryo, Fruchtknote.
Empyreumatic substances, Röstprodukte.
Enamel, Glasur; Emaille.
— paint, Emaillefarbe.
Endosperm, Mehlkörper.
Engine, Dampfmaschine.
Epithelium, Oberhaut.
Epsom salts, Bittersalz.
Equation, Gleichung.
Equilibrium (mech.), Gleichgewicht.
Erecting (mech.), montiren.
Essential oil, ätherisches Oel.
Ethylalcohol, Gärungsalkohol; Aethylalkohol.
Evaporating efficiency (coal), Heizwerth.
Evaporation, Verdampfung.
Excavate, ausgraben.
Excess, Ueberschuß.
Excise duty, Steuern.
Excretion, Absonderung.
Exhaust steam, Abdampf; Auspuff.
Expansion, Ausdehnung.
External mash machine, Vormaischapparat.
Extract, Auszug.
— apparent, scheinbarer Extrakt.
— real, wirklicher Extrakt.
Eye piece (mic.), Okular.

Farinaceous, mehlig.
Fat globules (bot.), Fettkügelchen.
Faucet, Zapfen.
Feed, Futterstoff.
— beer (top f.), Bier zum Nachstechen.
— pump, Speisepumpe.
— water heater (mech.), Vorwärmer.
Felt (malt), verfilzen, gabeln.
Ferment, vergären.
Fermentable, vergärbar.
Fermentative energy, Gärvermögen.
— power, Gärkraft.
Fermentation, Gärung.
Fermenter, Gärbütte.
Fermenting test, Gärkraftbestimmung.
— tub, Gärbütte.
Field of view (mic.), Gesichtsfeld.
Fiery fermentation, stürmische kochende Gärung.
Filled up (cask), spundvoll.
Film, Kahm.
Filter disk, Stoffrahmen.
Final attenuation (beer), Endvergärungsgrad.
— temperature (kiln), Abdarrtemperatur.
— temperature (mash), Abmaischtemperatur.
Fine, to, schönen.
Finger-nail test, Nagelprobe.
Fining out, Ausstoßen.
Finings, Schöne.
Finished (fermenting beer), vergoren.
— wort, Ausschlagwürze.
Finishing temperature (kiln), Abdarrtemperatur.
Fir, Kiefer.
Firkin (measure), halber Eimer.
Fire clay, Chamotte.
— copper, Feuerkessel.

Flinty (barley), spe
Float, Schwimmer; S
Floating attempera
— barley (idlers
Floor (malt), Tenne;
— (of malt), Hau
Flooring, Haufenfüh
Flue boiler, Flamm
Flues, Feuerkanäle.
Fluidity, Dünnflüssi
Foam, Schaum.
— holding capac
bigkeit.
Fobbing, Schäumen
Focal length, Bren
Focus, Brennpunkt.
Food (yeast), Hefen
Foot pound (mech.)
Forced draft, forcier
Forceps, Pinzette.
Fore-masher, Vorm
Foxy, fuchsig.
Fraction (math.), B
Freezing mixture,
Fret, stürmische Lage
Fretting fermentat
ung.
Friability (malt), M
Friction (mech.), R
— clutch, Bremse
— pulley, Frictio
Frothing, schäumen.
Fuel, Brennmaterial;
Fulcrum, Stützpunkt
Full-bodied, vollmun
Fungi, Pilze.
Funnel, Trichter.
Fuse, Zündschnur.
— to, schmelzen.
Fusel oil, Fuselöl; A
Fusible plug, schmel

Grains (spent), Treber.
— remover, Austreberborrichtung.
— valve, Maischventil.
— water, aus Trebern gepreßte Flüssigkeit.
Grape sugar, Traubenzucker.
Grate (mech.), Rost.
Gravity (physics), Anziehungskraft.
— of wort, Stammwürze.
— specific, specifisches Gewicht.
Green malt, Grünmalz.
— vitriol, Eisenvitriol.
Grind (malt), quetschen; mahlen.
Grist, Schrot. (Schüttung.)
— case, Malzschrottrichter.
Grits, geschrotener, enthülster weißer Mais.
Groove, Fuge; Rinne.
Grooving iron, Spundhobeleisen.
Grounds, Geläger.
Grown out (malt), ausgewachsen.
Growing floor, Keimtenne.
Growth (malt), Wachsthum.
Gyle, Sud.
— tun (top f.), Gärbütte.
Gypsum, Gips; schwefelsaurer Kalk.

H.

Handrake, Rührscheit, Maischkrücke, Maischscheit.
Hardening tower, Thurm zum Härten des Brauwassers.
Hardness, Härte.
Haze, haziness, Schleier.
Head (beer), Schaum; Schaumstand.
— (fermentation), Kräusen.
Head mold, Kopfschimmel.
Heap, Haufen.
Heaping up (malt), Haufenziehen; zusammensetzen.
Heat capacity, Wärmevermögen.
— unit, Wärmeeinheit.
— value, Heizwerth.
— of evaporation, Verdampfungswärme.
— of solidification, Erstarrungswärme.
Heater (mech.), Vorwärmer.
Heats (top f.), Temperaturen.
Hickory, weiße amerikanische Wallnuß.
High fermentation, Obergärung.
Hoist, Aufzug.
Hoop, Reifen.
Hop back, Ausschlagbütte.
— jack, Hopfenseiher.
— mill, Hopfenzerreißmaschine.
— oil, Hopfenöl.
— resin, Hopfenharz.
— retention, Würze von Hopfen zurückgehalten.
— sickness (top f.), abnormale Nachgärung hervorgerufen durch Saccharomyceten des Hopfens.
Hopper, Malztrichter.
Hopping down, Hopfengeben.
Horizontal, wagerecht.
— machine, liegende Maschine.
Horse power, Pferdekraft.
Hose, Schlauch.
Hull, Hülse.
Husk, Hülse.
Hydrochloric acid, Salzsäure.
Hydrogen, Wasserstoff.
Hyphae, Mycelfäden.
Hyphomycetes, Fadenpilze, Schimmelpilze.

I.

Idlers (barley), leichte Körner.
Ignition, Entzünden, Glühen.
Ill-vegetated (malt), schlecht gewachsen.
Impermeability, Undurchdringlichkeit; Wasserdichte.
Incandescent light, Glühlicht.
Inclined plane (mech.), schiefe Ebene.
Increase (malting), Gewichtszunahme.
Incrustation, Kesselstein.
Incubator, Brutkasten.
India rubber, Gummi.
Indian corn, Mais.
Inert, träg.
Infusion method, Wassermaische; Aufgußverfahren.
Initial heat, Einmaischtemperatur.
Injector, Dampfstrahlpumpe.
Inoculate, impfen.
Insulation, Isoliermaterial.
Internal revenue, Binnensteuer.
Invert, to, verzuckern.
Involution form (bacteria), unregelmäßig geschwollene Formen.
Iodine solution, Jodlösung.
— test, Jodprobe.
Isinglass, Hausenblase; Klärgelatine.

J.

Jacobs ladder, Transporteur.
Jet (mech.), Strahl.
— condenser (mech.), Spritzkondensator.
Joint, Gelenk; Glied.
Joist, Querbalken.
Journal bearing, Achsenlager; Zapfenlager.

Kettle, Braukessel.
— man, Bierlader.

— fitness (malt),

L.

Label, Etikette.
Lacquer, Lack.
Lactic acid, Milchsäure.
Lantern (mech.), Schauglas.
Last run, Glattwasser.
Latent heat, gebundene Wärme; latente Wärme.
— — of fusion, Schmelzwärme.
Lead on (yeast), verführen.
Leaker, undichtes Faß.
Lag screw, Schraubenbolzen.
Length of (wort), Parrelanzahl.
Lever (mech.), Hebel.
Levulose, Fruchtzucker.
Life (beer), Trieb.
Lift pump, Hebepumpe.
Lignite, Braunkohle.

Lining, Verkleidung.
Link-belt, Gliederkett
Linseed oil, Leinöl.
Liquid receiver (m
behälter.
Liquifaction, Verflü
Liquor (mash), Ma
Litmus paper, Lackm
Live steam, direkter
Load (building), Be
Low fermentation,
Lubricant, Schmierm
Lunchroom, brew
Braustube.
Lupuline, Hopfenbi
Hopfenmehl.
Lye, Lauge.

M.

Maggot, Made.
Magnesium chloride, Chlormagnesium.
Magnifying power (mic.), Vergrößerung.
Maize, Mais, Kukuruz.
Malleable, schmiedbar.
Mallet, Klopfholz.
Malt adjuncts, Malzsurrogate.
— bin, Malzkasten, Silo.
— crusher, Schrotmühle; Malz-

Maturity (barley),
Mealy malt, mehlig
Meat broth gelati
wassergelatine
Mechanical effect,
Mellow (malt), mürb
Mellowness (malt),
Melting point, Schm
Methyl alcohol, Hol
Micrometer screw (n

N.

Naked steam, direkter Dampf.
Nidus, Nährboden.
Nitrates, salpetersaure Salze.
Nitrites, salpetrigsaure Salze.
Nitrogen, Stickstoff.
Nitrogenous bodies, Eiweißkörper, Stickstoffkörper.
Non-sugar, Nichtzucker.
Nosepiece (mic.), Revolver.
Nucleus, Zellkern.
Nut (mech.), Schraubenmutter.
Nutritive substrata, Nährboden.

O.

Oak, Eiche.
Oakum, Werg.
Oats, Hafer.
Observing glass, Schauglas.
Oidium lactis, Milchschimmel.
Oil cup, Schmierbüchse.
— trap (mech.), Oelabscheider.
Origin, Abstammung.
Original density, Stammwürze.
— gravity, Stammwürze.
Original wort, Stammwürze.
Oscillatory, schwingend, rüttelnd.
Outcrop (yeast), Hefeernte.
Output, Ausstoß.
Outside mashing device, Vormaischer.
Over bunging, überspunden.
— cured malt, zu hoch abgedarrtes Malz.
Oxalic acid, Oxalsäure.
Oxygen, Sauerstoff.

P.

Packing (mech.), Verdichtungsring.
Paddle, Schaufel, Maischkrücke.
Paint, Anstrich.
Palate fullness, Vollmundigkeit.
Parachute (top f.), Hefetrichter in Gärbütte.
Parent cell, Mutterzelle.
Paste, Kleister.
Pathogenic, krankheiterzeugend.
Pearl ash, kohlensaures Kali.
Peat, Torf.
Peg, Stift, Zapfen.
Pellicle, Rahm.
Perforated, durchbrochen, durchlocht.
Permanent hardness (water), permanente Härte, bleibende Härte.
Petri dish, Petrische Schale.
Phosphate of potash, phosphorsaures Kali.
Piece (malt), Haufen.
— (mash liquor), Anschwänzwasser.
Pillow block, Stützlager.
Pinch cock, Quetschhahn.
Pinched, eingeschnürt.
Pine, Fichte; Tanne.
Pinion, Getriebe.
Pipe coil attemperator, Röhrenbottichkühler.
Piston (mech.), Kolben.
— travel (mech.), Kolbengeschwindigkeit.
Pitch, Pech.
— to (casks), pichen.
— (of floors), Fall.
Pitching (yeast), Zeuggeben.
— machine, Pichapparat.
Pitchy taste (beer), Pechgeschmack.
Pith, Zellgewebe.
Pivot, Zapfen, Stift.
Plaster of Paris, Gips, schwefelsaurer Kalk.
Pliers, Zange.
Plug, Pfropf, Stöpsel, Zapfen.
Plumule, Blattkeim.
Pneumatic conveyor (mech.), Lufttransporteur.
Poker, Schürhaken.
Ponto (top f.), geschlossene Gärbütte mit Mannloch oben zum Ausstoßen der Hefe.
Pony-masher, Vormaischapparat.
Poppet valve, Glockenventil.
Poplar, Pappel.
Porous, porös.
Port (engine), Dampfkanal.
Post hanger, Traglager.
Potassium permanganate, übermangansaures Kali.
Power, Kraft.
Precipitate, to, ausscheiden, niederschlagen.
Preservative, Konservierungsmittel.
Pressure, Druck.
— gauge, Druckmesser.
Primary battery, Element.
Prime, to, kräusen mit Zuckerlösung.
Principal fermentation, Hauptgärung.
Progeny, Nachkommenschaft; Brut.
Propagation, Fortpflanzung.
Proteid, Proteinkörper.
— turbidity, Eiweißtrübung.
Proteolytic, eiweißspaltend.
Pulley, Riemenscheibe.
Pulp, Faser.
Puncheon (top f.), Gärfaß.
Pure culture, Reinkultur.

Pure yeast, Reinhefe.
Purging (beer), reinigen durch Ausschaffen.
Putrefaction, Fäulniß.
Putrid fermentation, faulige Gärung.
Putty, Kitt.

Q.

Quicklime, Aetzkalk.

R.

Rack, to, abfüllen, fassen, schlauchen.
Rack and pinion, Zahnstange und Rad.
Racking bench, Abfüllbock.
— **gut**, Abfüllschlauch; Schlund.
— **square** (top f.), Abfüllbutte.
Radiation, Strahlung.
Radicle (bot.), Wurzelkeim.
Rake, Rechen.
Rancid, ranzig.
Ratchet (mech.), Zahnstange.
— **wheel**, Sperrrad.
Raw (taste), herb.
— **cereals**, Rohfrucht.
— **steam**, direkter Dampf.
— **wort**, ungekochte Würze.
Real attenuation, wirkliche Attenuation.
— **degree of attenuation**, wirklicher Vergärungsgrad.
— **extract** (beer), wirklicher Extrakt.
Red lead, Mennig.
Reducing sugars, Rohmaltose; durch Fehling's Lösung gefällter Zucker.
Refraction (opt.), Brechung.
Refresh yeast, herrühren, auffrischen.
Refrigerating machine, Kältemaschine.
Reproduction, Vermehrung.
Re-racking, umfüllen.
Re-rake, aufhacken, umstechen.
Resin, Harz, Kolophonium.
— **turbidity**, Harztrübung.
Residue, Rückstand.
Resistance, Widerstand.
Respiration (bot.), Ausathmung.
Rest, Rast.
Return wort, Hansel.
Returns, von Kunden zurückgesandtes Bier.
Reversing gear, Umsteuerung.
Revivification (yeast), Auffrischen, Herführen.
Revolutions (mech.), Touren.
Rice tub, Reisbütte.
Rider cask, Sattelfaß.
Rim fermentation, Randgärung.
Rinsing (casks), Faßschwenken.
Rivet hole, Nietloch.
Riveting, vernieten.
Roast (malt), rösten.
Rocking valve, Rundschieberventil.
Roller, Walze.
Roofing paper, Dachpappe.
Rootlet, Wurzelkeim.
Rope, Seil, Tau.
Ropy, fadenziehend.
Rosin, Kolophonium.
— **oil**, Harzöl.
Rotary pump, Wurzelpumpe, rotirende Pumpe.
Rotten fermentation, faulige Gärung.
Rounds (top f.), runde Gärbütten.
Rouse, to, aufziehen.
Rouser, Aufziehkrücke.
Rubble stone, Rollstein.
Run (wort), Ausschlag.
Running beer (top f.), Schankbier.
Rust (hops), Kupferbrand.
Rye, Roggen.

S.

Saccharify, verzuckern.
Saccharification, Verzuckerung.
Safety valve, Sicherheitsventil, Ueberdruckventil.
Sale, Verkauf; Verschleiß.
Saline constituents, Mineralbestandtheile.
Saponify, verseifen.
Saturated steam, gesättigter Dampf.
Scalding (mash), verbrühen.
Scale (beer), Bierstein.
— (boiler), Kesselstein.
— (weighing), Wage.
Scald, to, abbrühen.
Schizomycetes (bot.), Spaltpilze, Bakterien.
Screen, Sieb.
Screw conveyor, Malzschraube, Transportschraube, Schneckentransporteur.
Seasoning (casks), auswittern, [illegible].
Second mashing, Aufmaischen.
Secondary fermentation, Nachgärung.
Secreting, ausscheiden.
Section, Durchschnitt.
Sediment, Trub, Geläger, Bodensatz.
— **bag**, Trubsack.
Sedimentation glass, Zeugglas.
Sedimentary yeast, untergärige Hefe.
Seed-yeast, Samenhefe, Kernhefe.
Set in fermentation, ankommen.

Set screw, Stellschraube.
Setting taps (wort), anzapfen.
Settling tank, Absitzbütte, Sammelbottich.
Sewage, Abwasser.
Sewer, Abzug, Kanal, Kothschleuse.
Shade of color, Farbenton.
Shaft (mech.), Welle.
Shavings, Späne.
Shell, Hülse.
Shipping beer, Versandt-, Export-Bier.
— cask, Transportfaß.
Shot, Schrot.
Shrinkage, Schwinden, Schwendung.
Siamese (mech.), Dreiwegverbindung; Faullenzer.
Sick fret, krankhafte Nachgärung.
Silica, Kieselsäure.
Silicate of soda, Wasserglas, kieselsaures Natron.
Single acting (mech.), einfachwirkend.
Sink, Ausguß.
Sinkers, Tauchkörner.
Six-row barley, sechszeilige Gerste.
Skim, to, abschäumen, abschöpfen, abheben.
Skimmer, Schaumlöffel.
Skimming system (top f.), Abschäumsystem, Bottichgärung.
— point, Zeit zum Hefeabschäumen.
Skimmings, Schwimmgerste.
Slack malt, feuchtes Malz.
Slaked lime, gelöschter Kalk.
Slide (mic.), Objektträger.
— (mech.), Schieber.
— valve, Muschelschieber; Schieberventil.
Slime-forming bacteria, Schleimbakterien.
Slotted (false bottom), geschlitzt.
Sluggish fermentation, träge Gärung.
Sluices (top f.), seitliche Schieberöffnung in dem oberen Theile der Gärbütte.
Smoke consumer, Rauchverbrenner.
— stack, Schornstein.
Smut (bot.), Brand.
Soak, to, weichen, einwässern.
Soda ash, gebrannte Soda.
— lye, Natronlauge.
Solder, to, löthen.
Solid extract, Trockensubstanz, -extrakt.
Solubility (malt), Auflösung.
Sounds, getrocknete Fischblase.
Sparger, Ueberschwänzer, Anschwänzer.
Sparging, überschwänzen, anschwänzen, aussüßen.
— heat, Temperatur des Ueberschwänzwassers.
— water, Ueberschwänzwasser, Nachguß.
Spark arrester (mech.), Funkenfänger.
Specific gravity, specifisches Gewicht.
— heat, specifische Wärme.
Speckled, gefleckt.
Speed, Geschwindigkeit.
— *of attenuation, Gärdauer.*
Spent grains, Treber.
— hops, Hopfentreber.
— malt, Malztreber.
Sphere, Kugel.
Spigot, Zapfen, Faßhahn.
Spike (bot.), Aehre.
— (mech.), Bolzen, Spiker.
Spile, Pflock, Zapfen.
Spiling (top f.), Fässer anbohren.
Splitting up (chem.), spalten.
Spontaneous combustion, Selbstentzündung.
Sporulation, Sporenbildung.
Spraying nozzle, Spritzkopf.
Spring (mech.), Feder.
Sprinkler, Brause; Gießkanne.
Sprocket wheel (mech.), Kettenrad.
Sprout, to, sprossen.
Sprouts, trockene Malzkeime.
Spurging out, ausstoßen.
Spurr wheel, Stirnrad.
Stab culture (mic.), Stichkultur
Stability, Haltbarkeit.
Stage (mic.), Objekttisch.
Stalė, schal.
Stamp (beer), Stempelmarke.
Stand (mash.), Ruhperiode.
Standard instrument, Normalinstrument.
Starch granules, Stärkekörner.
— turbidity, Stärketrübung.
Start (fermentation), ankommen.
Starter, Anstellbottich.
Starting tub, Anstellbottich.
Stave, Daube.
Stay-bolt, Spange.
Steam chest (mech.), Dampfraum.
— coil, Dampfschlange.
— jacket, Dampfmantel.
— kettle, Dampfbraupfanne, Kessel.
— sterilizer, Dampftopf.
— trap, Dampfwassertopf.
Steaming, pasteurisiren.
Steely (malt), glasig.
Steep, to, einweichen.
— tank, Quellstock, Weichbütte.
— water, Weichwasser.
Steeped (barley), gequellt.
Stem (saccharometer), Spindel.
Stenchy fermentation, faulige Gärung.
Stencil, Schablone.
Stewing wort, Würze im Kessel halten.
Stillion, Gärfaß.
Stinker (top f.), übelriechende Versandtgebinde.
Stirrer (mash), Maischmaschine; Maischgitter.
Stock beer, Lagerbier.
— cellar, Ruhkeller.
— tub, Ruhfaß.
Stoker, Heizer.
Stone square (top f.), Schiefergärbütte.
Stop cock, Absperrhahn.
Stopper, Pfropfen, Stöpsel, Verschluß.
Storage cellar, Ruhkeller, Lagerkeller.
— vat, Ruhbütte, Lagerfaß.

Store, to, lagern.
Strain, to, abläutern.
Straining vat, Läuterbottich.
Strata, Schicht.
Streak culture (mic.), Strichkultur.
Strength (wort), Saccharometeranzeige der Würze.
Strike (wort), ausschlagen.
Striking heat (top f.), Temperatur des Einmaischwassers.
Strobile (hops), Dolde.
Stroke (mech.), Hub.
Stuffing box (mech.), Stopfbüchse.
Submerged condenser, Tauchkondensator.
Succinic acid, Bernsteinsäure.
Suction pump, Saugpumpe.
Sugar, Zucker.
— of milk, Milchzucker.
Sulphate, schwefelsaures Salz, Sulfat.
— of lime, schwefelsaurer Kalk, Gips.
— of magnesia, schwefelsaure Magnesia, Bittersalz.
— of potassium, schwefelsaures Kali.

Sulphate of sodium, schwefelsaures Natron, Glaubersalz.
Sulphide, Schwefelverbindung, Sulfid.
Sulphite, schwefligsaures Salz.
Sulphuretted hydrogen, Schwefelwasserstoff.
Sulphuric acid, Schwefelsäure.
— — bulb, Schwefelsäureverschluß.
Sulphuring, schwefeln.
— (casks), einbrennen.
Sulphurous acid, schweflige Säure.
Superheated steam, überhitzter Dampf.
Support, Unterlage; Ganter; Lager.
Surface attraction, Oberflächenanziehung.
— condenser, Oberflächenkondensator.
— cooler, Kühlschiff.
— water, Grundwasser.
Swan necks (top f.), auf Gärfässern aufgesetzte Röhren zum Hefeausstoßen.
Synthetical, verbindend, aufbauend, synthetisch.
Syphon, Heber.

T.

Tallow, Talg; Unschlitt.
Tank, Behälter, Bütte.
Tanking (beer), fassen.
Tannic acid, Gerbsäure.
Tannin, Gerbstoff.
Tap, to, anzapfen, anstechen.
— heat, Temperatur der Würze beim Anzapfen.
— room, Sternewirth.
Tapering, kegelförmig, spitzig zulaufend.
Taps (mash tub), Wechsel, Hähne.
Tar, Theer.
Tart (taste), herb, scharf, sauer.
Tartar, Weinstein.
Tartaric acid, Weinsteinsäure.
Templet, Schablone.
Temporary hardness, temporäre, vorübergehende Härte.
Tensile strength (mech.), Zugkraft.
Tension, Spannung.
Test tube, Reagensglas.
Thick-mash, Dickmaische.
Thin the floor (malt), Haufenziehen.
Thread (mech.), Gewinde.
Three way cock, Dreiweghahn.
Throttle valve (mech.), Dampfabsperrventil.
Tile, Deckziegel.

Tin, Zinn, Weißblech.
Tinfoil, Staniol.
Top fermentation, Obergärung.
Topping (beer), lappeln.
— up, nachstechen.
Torrefy, to, rösten.
Torrefaction products, Röstprodukte.
Trade packages, Transportgebinde.
Transmission of power, Kraftübertragung.
Trap, Verschluß.
— (mashtub), Maischventil.
— door, Fallthür, Klappe.
Traveling crane, Laufkrahn.
Tripod, Dreifuß.
Trough (yeast), Bränke, Mulde.
Truck, Karren.
Trycock, Zwickel, Probierhahn.
Tub, Bütte, Bottich, Zuber.
Tube (mic.), Mikroskoprohre.
Tubular flue boiler, Flammrohrkessel.
Tun, Bütte, Faß.
— to (beer), fassen, umschlauchen.
Turbid, trüb.
Turn out (wort), ausschlagen.
Turning (beer), umschlagen.
— (malt), umschaufeln, stechen.
Type of yeast, Heferasse.

U.

Ullage, Auffüllquantum.
Underback, Ausschlagbutte, Grand.
Under-dough, Unterteig.
Underlet, Wasserzuführröhre an der Maischbutte, Pfaff.

Unfermentable, unvergärbar.
Uniformity, Gleichförmigkeit.
Union (top f.), Gärungsfaß.
Unmalted cereals, Rohfrucht.
Upright machine, stehende Maschine.

V.

Vaporization, Verdunstung.
Variety, Art.
Varnish, Faßglasur, Firniß.
Vat, Bütte, Bottich, Faß.
Vatting (top f.), Lagern in der Bütte.
Vegetable albumen, Pflanzeneiweiß.
— glue, Pflanzenleim.
Vegetated (malt), gewachsen.
Vent, Luft-krahn, -ventil.
Ventilating pipe, Dunstschlauch, Dunstrohr.
Vertical, senkrecht.
Vessel, Bütte, Faß.
Viscous fermentation, schleimige Gärung.
Vital yeast, gärkräftige Hefe.
Vitreous, glasig.
— malt, Steinmalz.
Vitrify, verglasen.
Volatile, flüchtig.
Volume, Masse, körperlicher Inhalt.

W.

Walnut, Wallnuß.
Wash (yeast), schlemmen.
Washing (casks), wichsen.
Washer, Mutterreifen.
Waste pipe, Abzugsrohr.
— products, Nebenprodukte.
Water (yeast), wässern.
— bath, Wasserbad.
— cooling tower, Gradirwerk.
— tube boiler, Wasserrohrkessel.
Wedge, Keil.
Weevil, Kornkäfer.
Welding, schweißen.
Wheat malt, Weizenmalz.
White lead, Bleiweiß, kohlensaures Blei.
Whitening, Schlemmkreide.
Whitewash, Kalkmilchanstrich.
— to, weißen.
Wild yeast, wilde Hefe, Kalthefe,
Wilds (malt), Husaren.
Wiring, verdrahten.
Wire rope transmission, Drahtseiltrieb.
Wither, to, schwelken.
Wood alcohol, Holzgeist, Methylalkohol.
Work out (beer, yeast), ausstoßen, ausschaffen.
Worm gear, Schraube ohne Ende.
Wort, Würze.
Wrench (mech.), Schraubendreher.
Wrought iron, Schmiedeeisen.

Y.

Yeast bouillon, wässeriger Hefeauszug.
— bite, bitterer Geschmack, von Hefe herrührend
— change, Hefewechsel.
— cell, Hefezelle.
— counting apparatus, Hefezählapparat.
Yeast food, Hefenahrung.
— rake, Zeugscheffe.
— rouser, Satzkrücke.
— tub, Zeugwanne.
— turbidity, Hefetrübung.
Yield, Extraktausbeute, Ausbeute.
Young floor, Junghaufen.

Z.

Zymogenic, gärungserregend.

l-behälter (mech.), liquid re-
eiver.
iges, anhydrous ammonia.
eriges (Aqua), aqua ammonia.
, come through; beginning
f fermentation.
, to work.
s, brewer's boots.
apparat, sparger.
en, to sparge.
(Bier), to tap.
tich, starting tub.
to pitch with yeast.
(Faß), take apart.
, to tap.
skraft (phys.), attraction.
ety.
andtheile, mineral substances.
, ash-pit or box.
s Öl, volatile or essential oil
austic potash.
, quick lime.
ron, caustic soda.
n (Gerste), change steep water.
se), refreshing; revivifica-
on.
rfahren, infusion method.
(Treber), re-rake.
n, adding kraeusen.
dissolve.
ohne), cutting.
(Malz), mellowness; friabil-
y; solubility.

Aufmaischen, second mashing.
Aufschließen, (Stärke), convert.
Aufstechen (Malz), trimming the piece.
Aufziehen (Hefe), to rouse; agitate.
Aufziehkrücke, rouser.
Aufzug, hoist; elevator.
Ausarten (Hefe), degenerating.
Ausathmen (Weichgut), respiration of growing barley.
Ausbeute, yield.
Ausbreiten (Tenne), to floor.
Ausbrühen, to scald.
Ausdehnung, expansion.
Ausfeuern (Fässer), fire heating interior of cask.
Ausgewachsen (Malz), grown out.
Ausgraben, excavate.
Auskellern, to clear cellar.
Ausschank, tapping or serving; to put on draught.
Ausscheiden, secrete; precipitate.
Ausschlag, run of wort from kettle.
— bütte, underback; hop-jack.
— würze, finished wort.
Ausstoß (Bier), output.
— system (Oberg.), cleansing system.
Ausstoßen, fining out; spurging out; working out of bunghole.
Aussüßen, sparging.
Austrebervorrichtung, grains remover.
Auswuchs (Gerste), growth, germination.
Auszug, extract.
Autoclave, digestor.

B

irder; beam.
Würze), saccharometer (Bal-
ng's) indication.
le, cotton.
lsamenöl, cottonseed oil.
b.), beaker.
k, bucket elevator.
, load.
re, benzoic acid.
gskondensator, atmospheric or
pen air condenser.
äure, succinic acid.
gung, accelleration.
eil, constituent.
ncrete.
ntrolle, control of brewing
perations.
o bolt.
e, check.
enbung, beer shrinkage.
er, kettleman.
; beer scale; extract deposit.
ter, internal revenue.
(*Weichgut*), test by biting.
Epsom salt; sulphate of
gnesia.

Blasengärung, bubble fermentation.
Blattkeim, acrospire.
Bleibende Härte, permanent hardness.
Bleiweiß, white lead.
Blende (mil.); diaphragm; stop.
Boden-satz, deposit; sediment.
— teig (Unterteig), underdough.
Bogenlicht, arc light.
Bolzen, bolt; spike.
— mutter, nut.
— scheibe, washer.
Bouquet, flavor.
Borsäure, boric or boracic acid.
Bottich (Bütte), vat; tank; tub; back.
Bouillon Gelatine, meatbroth gelatine.
Brandmarken, branding.
Bränke, yeast tub.
Braunkohle, lignite.
Braunkräusen, fuzzy heads.
Brause, sprinkling can; rose.
Braustube, brewers' lunch room.
Brechen (Malz), crushing; grinding.
Brechhaufen (Malz), heap when rootlet appears.
Brechung (opt.), refraction.
Bremse (Mech.), friction clutch; brake.

Brenn-eisen, branding iron.
— material, fuel.
— punkt (Phys.), focus.
— weite (Phys.), focal length.
Bruch (Würze), break.
— (Math.), fraction.
Brutkasten, incubator.
Buche, beech.
Büchsenmetall, babbitt metal.
Bürste, brush.
Bütte, tub; back; vat; tank.
Buttersäure, butyric acid.

C

Calorie (phys.), heat unit; calory.
Ceder (rothe), American cedar.
Charmotte, fire clay.
Chlor-calcium, chloride of calcium.
Chlorkalk, chloride of lime, bleaching powder.
— magnesium, chloride of magnesium.
— natrium, common salt; chloride of sodium.

D

Dachpappe, roofing paper.
Dampf-absperrventil, throttle valve.
— braupfanne, steam kettle.
— kanal (Maschine), port.
— kessel, boiler.
— mantel, steam jacket.
— maschine, steam engine.
— raum (mech.), steam chest.
— schlange (mech.), steam coil.
— strahlpumpe (mech.), injector.
— topf, steam sterilizer.
— wasserableiter (mech.), steam trap.
Dampfer, converter.
Darauflassen (Mälz.), doubling.
Darren, to kiln; kiln-dry; cure.
Darr-boden, kiln floor.
— mann, kilnman.
— malz, kiln-dried malt, cured malt.
— reife (Malz), kiln fitness.
Daube, stave.
Dauersporen, resting-spores.
Deck-blätter (Hopfen), bracts.
— glas, cover-glass.
— ziegel, tile.
Decke (gärendes Bier), cover.
Diastatische Kraft, diastatic power.
Dichte der Körper (Phys.), density.
Dickmaische, decoction or thick mash.
Direkter Dampf (mech.), live steam; naked steam.
Dolde (Hopfen), cone; strobile; catkin; umbel.
Doppelt-kohlensaures Natron, bicarbonate of soda.
— schwefligsaurer Kalk, bisulphite of lime.
— schwefligsaures Natron (Kali), bisulphite of soda (potash).
— wirkend (mech.), double acting.
Drahtseiltrieb (mech.), wire rope transmission.
Dreifuss, tripod.
Dreiweg-hahn, three-way cock.
— verbindung, siamese; Y connection.
Druck, pressure.
— messer (mech.), pressure gauge.
Drüse, gland.
Drüsen (Hopfen), lupulin.
Dunstschlauch, ventilating pipe.
Durchbrochen, perforated.
Durchbruch (Kräusen), collapse of krausen head.
Durchfallen (gärendes Bier), clearing; to fall back (krausen).
Durchmesser, diameter.
Durchschlagen, rubbing through sieve.
Durchschnitt, average; section.

E

Eiche, oak.
Eimer, bucket; pail.
— (Maass), [illegible].
— [illegible].
Einbrennen (Fass), to sulphur cask.
Eindampfen, concentrating.
Einfachwirkend, single acting.
Eingedickt, [illegible]; concentrated.
Einkellern, to lay in casks or tubs.
[illegible], holding down [illegible].
Einmaischen, doughing in.
Einmaischtemperatur, initial temperature.
Einstellung (Mech.), adjustment.
Einteigen, doughing in.
Einweichen, soaking.
Eisenvitriol, green vitriol; sulphate of iron.
Eiweisskörper, albuminoids; nitrogenous bodies.
— spaltend, proteolytic.
— trübung, proteid turbidity.

:elet.), primary battery.
rbe, enamel paint.
rungsgrad, final attenuation.
n, degerminate.
n, ignition.
efe), outcrop; crop.
ngswärme, heat of solidifica-
ion.

Essig-mutter, mother of vinegar.
— säure, acetic acid.
Etikette, label.
Extrakt-ausbeute, yield.
— scheinbarer, apparent extract; balling of beer.
— wirklicher, real extract of beer.

F

hend (Bier), ropy.
zeugend, chromogenic.
, roast malt; amber malt.
ılp; fiber.
k; barrel.
reiben, scraping prior to
'arnishing.
:ungssystem (Oberg.), cleansing
ystem.
äger, cask deposit.
fur, varnish.
el, brewer's coat.
nel, cross beam.
maschine, keg rolling machine.
upfen, entering cask through
nanhole.
venken, to rinse.
r, manhole door.
Bier), to tun; to rack.
c, siamese or Y connection.
Gährung), rotten; stenchy.
putrefaction.
:ch.), spring.
schraube (mik.), micrometer
crew.
er, rock or tunnel cellar.
chen, fat globules.
Malz), slack malt.
ammer (mik.), moist chamber.

Feuchtigkeit, moisture.
Feuer-kanal (mech.), flue.
— kessel, fire copper, (kettle).
Fichte, pine.
Filtermasse, pulp.
Firniß, varnish.
Fisch-blase, sounds, isinglass.
— leim, isinglass.
Flammrohrkessel (mech.), tubular or flue boiler.
Flantsche (mech.), flange.
Flaschenbier, bottle beer.
— Abtheilung, bottling department.
Flaschenzug, block and tackle.
Flüchtig, volatile.
Flüssiges Ammoniak; anhydrous or liquid ammonia.
Forcirter Zug (mech.), forced draft.
Fortpflanzung, propagation.
Frictionsscheibe (mech.), friction pulley.
Frucht-knote, embryo.
— zucker, levulose.
Fuge, groove,
Fuhrfaß, carriage cask.
Funkenfänger (mech.), spark arrester.
Fuselöl, fusel oil; amylic alcohol,
Fußpfund (mech.), foot pound.
Futterstoff, feed.

G

Malz), to mat; to felt; to cake.
t, Bottich, fermenter; ferm-
nting tub; (Oberg.) gyle tun;
ounds.
ıer, duration of fermentation;
peed of attenuation.
; (Oberg.), puncheon; stillion;
ınion.
rung, method of fermenta-
ion.
ft, fermentative power.
ftbestimmung, fermentative
est.
htig (Hefe), vital.
mögen, fermentative energy.
fermentation.
alkohol, grain or ethyl al-
hol.

Gärungs-beschleunigung (Malzmehl), dressing.
— erregend, zymogenic.
Gebinde, cooperage.
Gebläse, blast.
Gebräu, brew; gyle.
Gebundene Wärme, latent heat.
Gefleckt (Malz), speckled.
Gegendruck, counter or back pressure.
Gegengewicht, counterbalance, counterweight.
Gegenstromkühler, counter current cooler.
Gegenwelle, counter-shaft.
Geißeln (bot.), flagella.
Geläger, sediment; grounds.
Gelagert (Malz), stored, matured.
Gelenk, joint.

Gelöschter Kalk, slaked lime.
Gequellt (Gerste), steeped.
Gerbsäure, tannic acid.
Gerbstoff, tannin.
Gerinnen (Eiweiß), coagulate.
Gerippt, corrugated.
Gerste, barley.
Gesättigt, saturated.
Gesättigter Dampf, saturated steam.
Geschlitzt, slotted.
Geschwindigkeit, speed.
Gesichtsfeld (Mik.), field of view
Getreide, grain, corn.
— arten, cereals.
Getriebe, pinion.
Gewachsen, (Malz), vegetated; grown.
Gewinde (Schraube), thread.
Gewölbe, arch.
Gießkanne, sprinkler.
Gips, gypsum; plaster of Paris; sulphate of lime (calcium).
Glanz, brilliancy.
Glanzfein, brilliant.
Glasig, glassy; vitreous; steely.
Glasiren, varnishing.
Glasur, enamel; varnish.
Glattwasser, last run.
Gleichförmigkeit, uniformity.
Gleichgewicht (phys.), equilibrium.
Gleichung, equation.
Gliederkette (mech.), link belt.
Glockenventil, poppet valve.
Gradiren, to take indications of … charometer.
Gradirwerk, twig cooling device.
Grand, underback.
Greifen (Malz), to mat; to felt; to ca…
Grün fassen; racking from fermen… while fermentation inc… plete.
— malz, green malt.
Gummi, India rubber.
Gurtentransporteur, belt conveyor.
Guß (Wasser), mash liquor; —wate…
— eisen, cast iron; casting.

H

Haarröhrenanziehungskraft, capillary attraction.
Hafer, oats.
Hahn, tap; cock; spigot.
Haltbarkeit, stability; keeping property; durability.
Hammatich, bicarbonate of soda.
Hanfseiltrieb (mech.), manilla rope transmission.
Hängelager (mech.), drop hanger.
Hansel, return wort; last run kept from one brew to another.
Härte, hardness.
Harz, resin; rosin
— öl, rosin oil.
— trübung resin-turbidity.
Haufen couch; floor; piece.
— führen, couching; flooring.
— ziehen, to thin the floor.
Haupt-gärung principal fermentation.
— würze first wort.
Hausenblasen, isinglass.
Hausschwamm, mold.
Hebe-daumen (mech.), cam.
— pumpe, lift pump.
Hebel (mech.), lever.
— wage, beam scale; balance.
Heber (mech.), siphon.
Hefe, yeast, barm.
— ernte, outcrop; crop.
— gabe, quantity of yeast for pitching.
— geben, to pitch.
— nahrung, yeast food.
— pilze, budding fungi; blastomycetes.
Hefe-rasse, type.
— trübung yeast turbidity.
— zählapparat, Haematimeter.
— zelle; yeast cell.
Heizer (mech.), stoker.
Heizwerth, heating value; evaporati… efficiency.
Hengst (Malz), couch.
Herb (Geschmack), raw.
Herführen (Hefe), lead on with fi… wort; refresh yeast.
Herrichten (Holz), seasoning.
Herunterlassen (Würze), strike.
Hirschhornsalz, carbonate of ammon…
Hohl-maß, volume.
— spiegel, mirror.
Holz-faser cellulose; wood pulp.
— geist, wood spirit; wood or me… lic alcohol.
— kohle, charcoal.
Hopfen-geben, to hop; hopping dow…
— gerbsäure, tannic acid of hops
— harz, hop resin.
— mehl, lupulin.
— mehlthau, mildew on hops; b… blight.
— öl, hop oil.
— seiher, hop-jack.
— stopfen, dry hopping.
— treber, spent hops.
— zerreißmaschine, hop mill; h… tearing machine.
Horde, kiln floor.
Hub (mech.), stroke.
Hülse, hull; husk; shell.
Hubaren (Malz), wilds.

I

In Schutz halten (Fässer), arranging in tiers.
Impfen (Hefe), to inoculate; to seed.
Imprägniren (mit Kohlensäure), to charge; to carbonate.
Isobarometrischer Abfüllapparat, counter or back pressure racking device.
Isolirung, insulation.

J

Jodprobe, iodine test.
— lösung, iodine solution.
Junghaufen (Malz), floor when roots show plainly.

K

Kahle Platten (Gärung), bare spots.
Kahm, film; pellicle.
— hefe, mycoderma.
Kalfatern, to calk.
Kalilauge, caustic potash.
Kalkmilch, milk of lime.
Kälte-maschine, refrigerating machine.
— mischung, freezing mixture.
Kalter Bruch, break of cold wort.
— Satz, cold water extract of malt.
Kalthefe, wild yeast.
Kammrad (mech.), cog wheel.
Kanalisation, drainage.
Kappeln (Bier), topping.
Karren, truck.
Kastanie, chestnut.
Kegel (mech.), cone.
— förmig, conical; tapering.
— rad, mitre or bevel wheel.
Keil (mech.), wedge; plug.
Keim (Malz), sprout; germ.
— apparat, germinating apparatus.
— kasten, germinating box.
— kraft, germinative power.
— tenne, germinating or growing floor.
Kellerei, cellarage.
Kellergeschmack, cellar taste.
Kennzeichen, characteristics.
Kern-hefe, seed yeast.
— spalte (Stärke), central split or opening.
Kessel, the copper; kettle; boiler.
— stein, boiler scale; incrustation.
— — mittel, boiler compound; purger.
Kettenrad (mech.), sprocket wheel.
Kiefer, fir.
Kieselsäure, silica.
Kipphordendarre, dumping kiln floor.
Kipprost (mech.), dumping grate.
Kitt, putty; cement.
Klammer, clasp; clamp.
Klappe, damper.
Klären, clarify.
Kleber, gluten.
Kleister, paste; gelatinized starch.
Klopfholz, mallet.
Knochenkohle, bone black; animal charcoal.
Kochdauer, duration of boiling.
Kochende (stürmische) Gärung, boiling fermentation; fretting.
Kochsalz, common salt; chloride of sodium.
— lösung, brine.
Kohlehydrat, carbo-hydrate.
Kohlen-oxyd, carbon monoxide.
— säure, carbonic acid, carbon dioxide.
— saures Kali, carbonate of potash; pearl ash.
— saures Natron; soda ash; carbonate of soda.
— saurer Kalk, carbonate of lime; chalk.
— stoff, carbon.
Kolben (mech.), piston.
— (lab.), flask.
— geschwindigkeit, piston travel.
— schimmel, club mold; aspergillus.
Kolophonium, rosin.
Kondensator, condenser.
Konservirungsmittel, preservative.
Kopfschimmel, head mold; mucor.
Körnig (Malz), brittle.
Korn-käfer, weevil.
— motte, corn moth.
Kothschleuse, sewer.
Kraft (mech.), power.
— übertragung, transmission of power.
Krahn (mech.), derrick.
Krankhafte Gärung, morbid fermentation.
Krankheits-erzeugend, pathogenic.
— hefen, false or foreign yeasts.
Kräusen, head (early stage of fermentation).

Krummschnäbel, twisted berries peculiar to 6-row barley.
Küfer, cooper.
Kugel, sphere; ball; bulb.
— bakterie, coccus.
— gelenk, ball and socket joint or coupling.
Kühlauf, man at cooler.
Kühlschiff, surface cooler; cool ship.
Kukuruz, maize; corn.
Kulturhefe, culture yeast.
Kunsteis, artificial ice.
Kupfer-brand (Hopfen), smut; rust.
— vitriol, blue vitriol; sulphate copper.
Kuppel (mech.), coupling.
Kurbel (mech.), crank.
— zapfen, crank pin.

L

Lack, lacquer; varnish.
Lackmußpapier, litmus paper.
Lager, support.
— (mech.), bearing; journal.
— bier, lager beer; stock beer.
— faß, storage vat; stock tub.
— keller, storage cellar; stock cellar.
Langwerden (Bier), to get ropy.
Latente Wärme, latent heat.
Laufkrahn, traveling crane.
Lauter-faßen, rack beer when well fermented.
— maische, lautermash; liquid part of mash.
Läuter-batterie, underlet.
— bottich, straining vat; clarifying tub.
— hahn, tap.
Läuterrinne, grand.
Legierung, alloy.
Leinöl, linseed oil.
Leistungsfähigkeit (mech.), efficiency.
Liegende Maschinen, horizontal machines.
Lindenholz, basswood.
Lokalgeschmack, local characterist taste.
Löthen, soldering.
Lüften, aerate; ventilate.
Luft-krahn; vent.
— malz, air dry malt.
— transporteur, pneumatic conveyor.
— untersuchung, air examination.
— zug, draft.
Lupulingehalt, condition (of hops).

M

Made, maggot; mite.
Mais, Indian corn; maize.
Maisch-apparat, stirrer; mash machine.
— bottich (Butte), mash tun or tub.
— gitter, stirrer.
— kessel, thick mash copper.
— krücke, hand rake.
— pfanne, thickmash copper.
— scheit, hand rake.
— ventil, grains valve; trap.
— wasser, mash liquor.
Maischen, to mash.
Malz-aufguß, auszug, malt extract.
— boden, malt loft; store room.
— brecher, mühle, malt crusher; mill.
— darre, malt kiln; dryer.
— haufen, malt couch; heap; floor; piece.
— haus, malt house.
— kasten, malt bin.
— keim, malt sprout.
— keller, floor.
— mühle, malt mill.
— schraube, spiral conveyor.
— schrot, malt grist; crushed malt.
— schrottrichter, malt grist case; hopper above the mash tun.
Malz-silo, malt bin.
— surrogate, malt adjuncts.
— tenne, growing floor.
— treber, grains; spent grains.
— verschlag, malt bin.
— wendeapparat, malt turning device.
Malzsacken, bagging malt.
Mannloch, manhole.
Marktreif (Bier), condition (top f marketable.
Mehlig (Malz), mealy; farinaceous.
Mehlkörper, endosperm; starch body
— thau, mildew; blight.
Mehrcylindermaschinen, compound machines.
Menge, bulk; quantity.
Mennig, red lead.
Merkmal, characteristic.
Messing, brass.
Meßrohr (lab.), burette.
Mikroskoprohre, tube.
Milbe, mite; corn worm.
Milch-schimmel, milkmold; oidium lactis.
— säuregärung, lactic acid fermentation.
— zucker, sugar of milk.

Mineralbestandtheile, saline constituents; ashes.
Mischhefe, composite yeast.
Montiren (mech.), erecting; assembling.
Mörtel, mortar.
Mousseux, life.
Muffig, moldy; musty; fusty,
Mulde, trough.
Mürbe, mellow.
Muschelschieber (mech.), slide valve.
Mutter (mech.), bolt nut.
— scheibe, washer.
— zelle, parent cell.
Mycelfäden, hypha.

N

Nachgärung, after, secondary, or complimentary fermentation.
Nachgärungssystem (Oberg.), cleansing system.
Nachguß, sparging water.
Nachstechbier, feed beer.
Nachstechen, topping up.
Nachweichen, to couch.
Nagelprobe (Malz), fingernail test.
Nähr-boden, nutritive substratum; nidus.
— gelatine, nutritive gelatin.
— substrat, nutritive substratum.
Nahrung, aliment, food.
Naßhaufen (Malz), heap until the germination starts.
Natronlauge, caustic soda solution.
Nebenprodukte, by-products.
Nichtzucker, non-sugar.
Niederschlag, deposit; precipitate.
Nietloch, rivet-hole.
Normalinstrument, standard instrument.
Nutzeffekt (mech.), mechanical effect; efficiency.

O

Oberflächenanziehung, surface attraction; surface tension.
Oberflächenkondensator, surface condenser.
Obergärung, top or high fermentation.
Oberteig, upperdough.
Objekt-tisch (mik.), stage.
— träger (mik.), slide.
Öffnung (mik.), aperture.
Okular (mik.), eye piece.
Ölabscheider, oil trap.
Oxalsäure, oxalic acid.

P

Pappel, poplar.
Pasteurisiren, pasteurizing; steaming.
Pech, pitch.
— geschmack, pitchy taste.
Permanente Härte (Wasser), permanent hardness.
Petrische Schale, Petri dish.
Pfaff, underlet.
Pferdekraft, horse power.
Pflanzen-eiweiß, vegetable albumen.
— faser, cellulose; fiber.
— grün, chlorophyll.
— leim, vegetable glue.
Pflock, spile; plug.
Pfropf, plug; stopper.
Phosphorsaures Kali, phosphate of potassium.
Pichapparat, pitching machine.
Pichen, to pitch.
Pilze, fungi.
Pincette, forceps.
Pinselschimmel, brush mold; penicillium glaucum.
Pleuelstange (mech.), connecting rod.
Polirmaschine (Malz), malt polisher.
Porös, porous.
Preßhefe, compressed yeast.
Probierhahn, blow off or try cock.
Proteinkörper, proteids.
Pumpauf, second kettleman.

Q

Quellen, steeping.
Quell-reif (Gerste), thoroughly steeped.
Querschnitt, section; cross cut.
Quetschen (Malz), grinding; crushing.

R

Randgärung, rim fermentation.
Ranzig, rancid.
Rasse (Hefe), type.
Rastgärung, rest fermentation.
Rauch-darre, open or direct fire kiln.
— verbrenner, smoke consumer.
Reagenglas (lab.), test tube.
Rechen, rake.
Regulator (mech.), governor.
Reibung, friction.
Reife (Bier), age.
Reifen, hoop.
Reifestadium (Gerste), maturity.
Reine Gasse halten, clear track on floor.
Reinhefe, pure yeast.
— zucht, pure culture.
Reisbütte, rice tank or tub.
Revolver (mik.), nose piece.
Riemen, belt; strap.
— scheibe (mech.), pulley.
Rinne, groove; gutter.
Roggen, rye.
Rohmaltose, reducing sugars.
Rohfrucht, unmalted cereals.
Röhrenbottichkühler, pipe coil attemperator.
Rohrzucker, cane sugar.
Rost (mech.), grate.
Rösten, torrefy.
Röst-malz, black malt.
— produkte, torrefaction products.
Rübenzucker, beet sugar.
Rückschlagventil (mech.), check valve.
Rückstand, residue.
Ruh-bütte, storage vat; stock tub.
— keller, storage or stock cellar.
— periode (Maisch), rest period; the stand.
Rühr-scheit, hand rake.
— werk, mash machine.
Rundschieberventil, rocking valve.

S

Sackbänder, bag tying strings.
Salatmachen (Maischen), doughing in and standing mash very cold for a long time.
Salpetersäure, nitric acid.
Salpetersaure Salze, nitrates.
Salpetrigsaure Salze, nitrites.
Salz-säure, hydrochloric or muriatic acid.
— lösung, brine.
Samenhefe, seed yeast; middle yeast layer in fermenter.
Sammelbottich (Butte), starting tub, collecting vat; gathering square.
Sattelfaß, rider cask.
Satz, yeast; sediment; deposit.
— brauen, brewing with cold extract of malt.
— krücke, yeast rouser.
Sau (Darre), heat chamber.
Sauerstoff, oxygen.
Saug-pumpe, suction pump.
— rohr (Maischbottich), connecting pipe between mashtun and grand.
Säuregehalt, acidity.
Schablone, stencil; pattern; templet.
Schädlicher Raum (mech.), clearance.
Schal, flat; stale; insipid.
Schalander, brewers' lunch room.
Schankbier, draught keg beer.
Schauglas, sample glass; observing glass; lantern.
Schaum, foam; froth; head.
— (auf Bier), head.
— beständigkeit, foam-holding capacity.
— löffel, skimmer.
Scheibe, disc.
Schicht, strata; layer.
Scheinbare Attenuation, apparent attenuation.
Scheinbarer Extrakt, apparent extract, balling, gravity or density of beer.
— Vergärungsgrad, apparent degree of attenuation.
Schieber, slide; gate.
— ventil (mech.), slide valve; gate valve.
Schiefe Ebene (mech.), inclined plane.
Schimmeln, to mold.
Schimmelpilze, mold fungi; hyphomycetes.
Schlabberventil (mech.), check valve.
Schlammsammler (mech.), mud drum.
Schlauch, hose.
Schlauchen, transfer by hose.
Schlecht gewachsen (Malz), ill-vegetated.
Schleier, haze.
Schleimbildende Bakterien, slime forming bacteria.
Schleimige Gärung, viscous or ropy fermentation.
Schlemmen, to wash.
Schlemmkreide, whitening.
Schlicken, wedges.
Schlund, racking gut.
Schmelzbare Platte (mech.), fusible plug.
Schmelzen, to fuse.
Schmelz-punkt, melting point.
— wärme, latent heat of fusion.
Schmiedbar, malleable.
Schmiedeeisen, wrought iron.
Schmier-büchse (mech.), oil cup; lubricator.
— mittel, lubricant.
Schnellgärung, accelerated fermentation.

Schöne, finings; isinglass.
Schönen, to fine; to clarify.
Schöpflöffel, skimmer.
Schornstein, smoke stack; chimney.
Schrauben-bolzen, lag screw.
— mutter, bolt nut.
— scheibe, washer.
— dreher, wrench.
Schrot, grist; shot.
— mühle, grist mill; crusher; malt mill.
Schürhaken, poker.
Schüttung, extract-yielding materials.
Schwand (Gerste), shrinkage.
Schwarz liegen (Würze, Bier), cleared, settled.
Schwarze Spitzen (Gerste), blackened tips.
Schwefel-kohlenstoff, bisulphide of carbon.
— säure, sulphuric acid.
— — verschluß, sulphuric acid bulb.
— saure Salze, sulphates.
— wasserstoff, sulphuretted hydrogen.
Schwefeln, sulphuring (bleaching barley).
Schweflige Säure, sulphurous acid; sulphur dioxide.
Schwefligsaure Salze, sulphites.
Schweißen, welding.
Schwelken, air drying; withering.
Schwendung, shrinkage.
Schwimmer (Gärbütte), attemperator; swimmer, float.
Schwimmgerste, skimmings; float barley.
— körper, float.
Schwingend, oscillatory.
Sechszeilige Gerste, six-row barley.
Seihplatte, false bottom; strainer.
Seil, rope.
Selbstentzündung, spontaneous combustion.
— gärung, spontaneous fermentation.
Senk-boden, false bottom; strainer.
— grube, catch basin; cess-pool.
— wage, areometer.
Senkrecht, vertical.
Sicherheitsventil (mech.), safety valve.
Sieb, sieve; screen.
Sieben, to bolt; to sieve.
Sieden, to boil; ebullition.
Siedepunkt, boiling point.
Silo, bin.
Späne, chips, shavings.
— stopfen, chipping; adding chips through bunghole.
Spänfaß, chip cask.
Spange, stay-bolt.
Spaltpilze, fission fungi, schizzomycetes.
Spannung, tension.
Specifisches Gewicht (phys.), specific gravity.
Speckig (Gerste), flinty.
Speicher (Getreide), elevator.
Speisepumpe, feed pump; injector.
Spelze, chaff; husk; shell.
Spiegel (Würze, Bier), surface.
Sperrrad, ratchet wheel.
Spitzen, to chit.
Spitzglas, sedimentation glass.
Sporenbildung, sporulation.
Spreu, chaff.
Spritz-kondensator (mech.), jet condenser.
— kopf, spraying nozzle.
Sprossen, budding.
Spund, bung.
— apparat, bunging apparatus.
— büchse, bushing; bung bush.
— daube, bung stave.
— voll, brim full.
— zapfen, bung plug.
Spunden, to bung.
Stabbakterie, bacillus.
Stammwürze, original wort; balling of wort; original gravity or density.
Ständer, tank.
Stanniol, tin foil.
Stärke-kleister, gelatinized starch; starch paste.
— körner, starch granules.
— trübung, starch turbidity.
Staubsammler, dust collector.
Stechen (widdern), to turn.
Stehende Maschine, upright machine.
Steigraum (Kräusen), unfilled portion of fermenter.
Stein-malz, glassy or vitreous malt.
— mörtel, concrete.
Stellring (mech.), collar (on shaft).
— schraube, set screw.
Stempelmarke (Bier), stamp.
Sternewirth, tap room.
Steuer, excise duty; tax; customs.
Steuerung (mech.), gear.
Stich-kultur, stab culture.
— probe, pricking test.
Stickgas, carbonic acid.
Stickstoff, nitrogen.
Stift, peg; apprentice.
Stirnrad, spur wheel.
Stockig, musty; fusty (odor).
Stoffrahmen, filter disc.
Stopfbüchse (mech.), stuffing box.
Stöpsel, plug; stopper.
Strahl, jet (mech.); ray (opt.).
Strahlung, radiation.
Strichkultur, streak culture.
Strom, current.
Stürmische Gärung, boiling or fiery fermentation.
Stütz-lager (mech.), pillow block.
— punkt (mech.), fulcrum.
Sud, gyle; brew.
— haus, brew-house.

T

Talg, tallow.
Tanne, pine.
Taube Körner, idlers; barren grains.
Tauch-kondensator (mech.), submerged condenser.
— körner, sinkers.
Temperaturen, heats (top f...
Temperaturgrenzen, ranges of heat.
Temporäre Härte (Wasser), temporary hardness.
Tenne, floor.
Theer, tar.
Thon, clay.
Todter Punkt (mech.), dead center.
Ton (Farbe), shade of color.
Torf, peat.
Touren (mech.), revolutions.
Träg, inert.
Träge Gärung, sluggish fermentation.
Träger, beam; girder.
Traglager (mech.), post hanger.
Transmissionsaufzug, lift; elevator.
Transport-gebinde, trade packages; carriage cask.
Transport-schnecke, spiral or screw conveyor.
— schraube, spiral or screw conveyor.
Traubenzucker, grape sugar.
Treber, spent grains.
— aufhackmaschine, grains remover.
— wasser, liquid pressed from grains.
Trichter, funnel.
Trieb, life; head; condition.
Trockene Fäulnis, dry rot.
Trocken-substanz, dry residue.
— treber, dried grains.
Tropf-bier, rest beer from sediment bag.
— sack, sediment bag or strainer.
Tröpfchenkultur, droplet culture.
Trub, sediment from wort; dregs.
— sack, sediment bag or strainer.
Trüb, turbid.
Trübung, turbidity; cloudiness.

U

Überhitzter Dampf, superheated steam.
Übermangansaures Kali, permanganate of potassium.
Überschuß, excess.
Überschwänzen, sparging.
Übersieden, extra brew.
Überspunden, overbunging.
Ulme, elm.
Umfang, circumference.
Umfüllen, re-racking.
Umschaufeln, turning.
Umschlagen (Bier), to turn.
Umstechen (Treber), re-rake.
Umsteuerung (mech.), reversing gear.
Undurchdringlich, impermeable; waterproof.
Unschlitt, tallow.
Untergärige Hefe, sedimentary or bottom yeast.
Untergärung, bottom fermentation, low fermentation.
Unterteig, underdough.
Unthätig, dormant.
Unvergärbar, unfermentable.

V

Verbrennung, combustion.
Verbruhen (Maische), scalding of mash.
Verdampfung, evaporation.
Verdampfungswärme, heat of evaporation.
Verdichtungsring (mech.), packing ring.
Verdrahten (Flaschen), wiring.
Verdunstung, vaporization.
Verdünnungsmethode (Kulturen), dilution method.
Verfilzen, to mat; to felt.
Verflüssigung, liquefaction.
Vergärbar, fermentable; attenuable.
Vergärung, fermentation; attenuation.
Vergärungsgrad, degree of attenuation.
Verglasen (Malz), vitrify.
Vergoren, finished, fermented.
Vergrößerung, magnifying power.
Verkleidung, lining.
Verkleistern, gelatinize.
Verkorken (Flaschen), corking.
Vermehrung, multiplication, reproduction.
Vernietung (mech.), riveting.
Versandtbier, export or shipping beer.
Verschleiert, hazy.
Verschleiß, sale.
Verschluß, stopper; closure; seal.
Verschneiden, to blend.
Verseifen, to saponify.
Verstechen (Bier), to blend.
Verstellbar, adjustable.
Verzuckerung, saccharification; inversion.
Vitriolöl, oil of vitriol; sulphuric acid
Vollmundigkeit, palate-fullness; bod

DICTIONARY OF TECHNICAL TERMS.

Vorderwürze, first wort.
Vorlaufpumpe, circulator; wort pump.
Vormaischer, external or automatic mash machine; fore masher.
Vorschießen, circulate wort.
Vorübergehende Härte (Waff
rary hardness.
Vorwärmer, feed water hea
mizer.

W

Wage, scale; balance.
Wagerecht, horizontal.
Wallnuß, walnut.
— weißer, hickory.
Walze, roller, cylinder.
Wärme, heat.
— einheit, heat unit; calory.
— leiter, conductor of heat.
— vermögen, heat capacity.
Wasser-bad, water bath.
— gehalt, moisture.
— glas, waterglass; silicate of soda (potash).
— krahn, bibb; faucet.
— maische, infusion.
— rohrkessel, water tube boiler.
— standsglas, gauge glass.
Wasserstoff, hydrogen.
Wässern (Hefe), to water.
Wechsel; tap; cock.
Wegschieben (Kräusen), receding from rim.
Weich-bütte, steep(ing)-tank; cistern.
— stock, " " "
Weichwasser, steeping water
Weichen, to steep.
Weinstein, tartar.
— säure, tartaric acid.
Weißblech, tin.
Weizenmalz, wheat malt.
Welle, shaft.
Werg, oakum.
Werthbestimmung, determi
value.
Wichsen (Faß), washing.
Wickelgarn, wicking.
Widdern (Malz), to turn.
Widerstand, resistance.
Wilde Hefe, wild yeast.
Winkel, angle.
— rad, mitre or bevel wl
Wirkliche Attenuation, real at
Wirklicher Extrakt, real extra
of beer.
— Vergärungsgrad, real
attenuation.
Würze, wort.
Wurzelkeim, rootlet; radicle

Z

Zahnrad (mech.), cog wheel.
Zahnräderwerk, gearing.
Zange, tongs; pliers.
Zapfen (mech.), spile; plug; peg; journal; pivot; faucet.
— fechten, seeking employment and incidentally free beer by brewer.
— lager (mech.), bearing; journal.
— lagermetall, babbit metal.
Zell-gewebe, cell tissue.
— kern, nucleus.
— saft, cell juice.
Zelle, cell.
Zerfressung, corrosion.
Zerstäubungsapparat, atomizer; aerator.
Zeug, yeast; barm.
— geben, pitching with yeast.
— scheffel, yeast rake.
Zeugwanne, yeast tub.
Ziehen (Haufen), to couch; t
— (Würze), drawing off.
Zinn, tin.
Zuber, tub.
Zubrühen, addition of boil
in mashing.
Zucker, sugar.
Zug (mech.), draft.
— kraft (mech.), tensile st
Zündschnur, fuse.
Zurückgehen (Kräusen), fallin
Zusammenlaufbütte, gatheri
(top f.), settling tul
Zusammensetzen (Malz), hea
Zusammensetzung, composit
Zusammenziehung, contracti
Zuschlagen (Faß), to bung.
Zweizeilige Gerste, two-row
Zwickel, try cock.

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INDEX.

to pages.
like "and," "in," "of," etc., are neglected in the
gement of words.

ABBREVIATIONS.

ion.—Determ., determination.—Ils., illustrated.—Mach.,
rigerating.—T., table.

Abbe—Addition

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